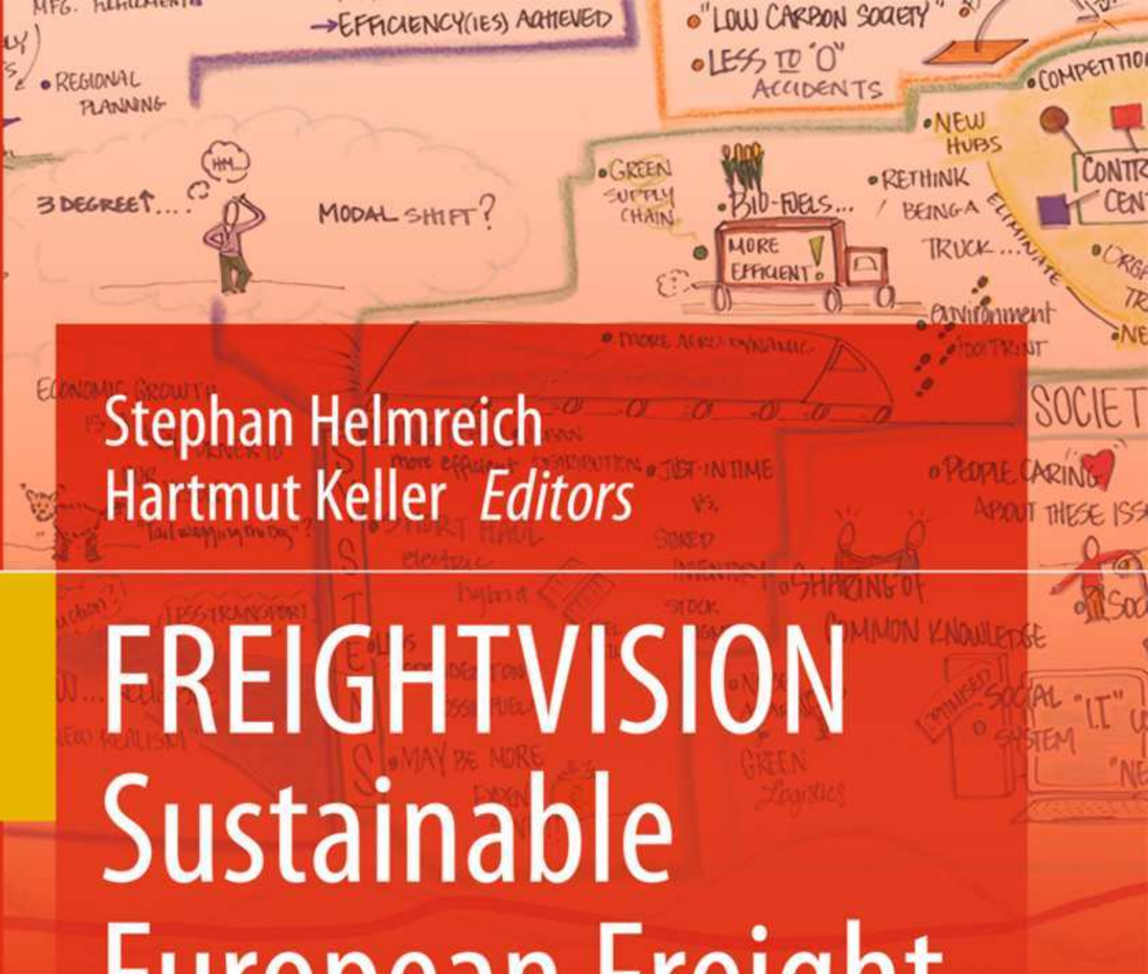

Stephan Helmreich
Hartmut Keller *Editors*

FREIGHTVISION Sustainable European Freight Transport 2050

Forecast, Vision and Policy Recommendation

Springer

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Forecast, Vision and Policy Recommendation

With 50 Figures and 87 Tables

Springer

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Preface

This book has been written on the basis of the research done between 2008 and 2010 as part of the European Commission funded FREIGHTVISION project.

The "FREIGHTVISION – Freight Transport 2050 Foresight" project was funded by the Directorate-General for Energy and Transport to design a long-term vision for European freight transport in 2050 and to identify actions and research to progress appropriate freight transport measures in Europe.

The project was carried out as a foresight process encompassing four conferences in which the project team identified and developed with the aid of more than 100 experts an action plan for securing long-term freight transport in Europe. The book provides insights into the freight-transport visions and backcasts identified for 2035 and 2050, issues which need to be addressed and measures which were assessed to be part of future paths to assure an economical, environmental and social freight transport system.

It is to be noted that the book represents the views of the authors and not necessarily those of the European Commission or the FREIGHTVISION Expert Group, either individually or collectively.

The FREIGHTVISION consortium was comprised of 13 organisations of 10 European countries:

AustriaTech – Federal Agency for Technological Measures, Vienna – Prime Contractor
CVUT – *Czech Technical University, Praha*
DTU – Technical University of Denmark, Kgs. Lyngby
EGIS Mobilité, Lyon
ICCS – Institute of Communications and Computer Systems, Athens
MOBYCON, Delft
The Chancellor, Masters and Scholars of the University of Oxford, Oxford
ProgTrans AG, Basel
SUOMEN YMPÄRISTÖKESKUS, Helsinki
TETRAPLAN A/S, Copenhagen
TRANSVER GmbH. Transport Research and Consultancy, Munich
TSB Innovationsagentur Berlin GmbH-FAV, Berlin
WU – Vienna University of Economics and Business, Vienna

In addition a major subcontract was given to the Austrian Institute of Technology (AIT) to support the project team. Although the AIT was no official member of the consortium, they were equally important for the project's results.

The FREIGHTVISION Project was divided into 8 Lead-Work-Packages which were coordinated and produced under the responsibility of the following partners:

1. Project Coordination	Stephan Helmreich
2. Policy	Ronald Jorna
3. Technology	Florian Kressler
4. External Factors	Olaf Meyer-Rühle
5. Forecasts	Jürgen Schmiele
6. Backcasts	Carine Vellay, Martin Volny
7. Vision and Action Plan	Stephan Helmreich
8. FREIGHTVISION Forum Meetings	Helena Kyster-Hansen

In addition the following major responsibilities were

• Modeling GHG emissions and FFS[1]	Tuomas Mattila, Riina Antikainen
• Modeling Congestion	Christian O. Hansen, Jeppe Rich
• FORESIGHT	Doris Wilhelmer, Klaus Kubeczko.

AustriaTech in Vienna, Austria served as a Prime Contractor of FREIGHTVISION. Thanks go to its Managing Director Reinhard Pfliegl for providing his support as well as the institution's facilities as an important contribution for the project's success.

The book is a joint effort of the FREIGHTVISION Team and presents the contributions of the individual authors and organisations within FREIGHVISION based on the deliverables and management reports of the project.

The editors and the individual authors would like to thank all experts who contributed to the discussions and development of understandings at the conferences which have formed a platform for this book. We wish to thank the European Commission, Directorate-General for Energy and Transport, for enabling and encouraging the 7th Framework Programme support action FREIGHTVISION, and in particular John Berry and Rein Jüriado, the project officers of the FREIGHTVISION project.

Stephan Helmreich and Hartmut Keller
Vienna and Munich July 2010

1 Fossil Fuel Share

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Part I
Introduction and Approach

1 Introduction

Stephan Helmreich and Hartmut Keller

Abstract This book has been written on the basis of the research done between 2008 and 2010, as part of the European Commission funded FREIGHTVISION project. The project's goal was to develop a long-term vision and action plan for a sustainable European long-distance freight transport system in 2050. The sustainability aspects addressed are greenhouse gas emissions, dependency on fossil fuels, accidents, and congestion. This chapter introduces the problem of reaching a sustainable freight transport system, and describes the objective, methodology, and conceptual framework of the book.

1.1 The Problem—Reaching a Sustainable Freight Transport System

The European Union faces the challenge to ensure and increase economic growth and to cope with an increasing freight transport demand and limited transport infrastructure in the next years and decades, while at the same time the transport system should become *sustainable*.[1] As the transport system "should be" sustainable, policy makers apparently realized that they did not succeed to develop a sustainable transport system in the past. But what does "sustainability" mean, and in which aspects did transport policy not succeed?

"Sustainability" is one of these words used by various interest groups with different focus. According to the Brundtland Report (United Nations, 1987), a sustainable development should

- "ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs", and
- ensure that the "poor get their fair share of the resources required to sustain that *(their economic)* growth".

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1 "The goal of the ETP (European Transport Policy) is to establish a sustainable transport system that meets society's economic, social and environmental needs . . .", (European Commission, 2009).

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- It is "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional changes are made consistent with future as well as present needs."

Sustainable development has to consider the three dimensions economy, environment, and society, and thus includes many different aspects, like food security, species and ecosystems, energy availability and peace, housing and health care.

With regard to European freight transport, not all sustainability aspects have the same relevance, e.g. European freight transport has limited impact on housing or peace. The European Commission funded project FREIGHTVISION, which is the basis of this book, therefore focused on a subset of sustainability aspects, which currently are considered as the most critical ones with regard to a sustainable European transport system, as their development apparently is not sustainable up to now. In addition, they were specifically mentioned in the mid-term review of the European Commission's 2001 Transport White paper. These aspects are greenhouse gas (GHG) emissions, fossil fuel share, road fatalities, and traffic congestion.

Concentrating on these four criteria does not mean that economic growth, social development, or other sustainability criteria are of minor importance to either the European Commission or the project. But the goal of the project was to elaborate recommendations for Directorate-General for Energy and Transport on how a sustainable development for these four criteria could be reached without negative impacts on other sustainability criteria.

1.1.1 An Unsustainable Development with Regard to GHG Emissions

The environmental aspect of European[2] transport was unsatisfying in the past. In Europe transport's GHG emissions[3] grew between 1995 and 2007 by about 17% (European Commission, 2010), whereas Europe's total emissions were reduced (−3%). Thereby transport's share increased from 16 to 19.5%. In this timeframe GHG emissions decreased in all sectors except the transport sector (European Environment Agency, 2009).

The major problem is the dynamic development, which is caused partly by a strong freight transport performance (in tonnes-kilometers) increase of 38%, which was higher than passenger transport growth (25% pkm[4]) and even slightly higher than economic growth (36%[5]). The technical improvements in freight transport were lower than transport demand increase.

If freight transport continues to have very strong growth rates in the future and will not be decoupled from GDP growth, there is definitely a sustainability problem,

2 EU-27.

3 CO_2 equivalents.

4 Passenger km.

5 GDP.

considering IPCC's[6] (IPCC, 2007) and Stern's (Stern, 2006) reports on environmental and economic risks involved with GHG emissions.

1.1.2 An Unsustainable Development with Regard to Fossil Fuel Share

In 2007 Europe's import dependency on oil was 82.6% (European Commission, 2010). Transport's dependency on oil is about 98% (European Commission, 2006). As oil seems to be a finite natural source, one of the main questions is, when this source will be exhausted. The term "Peak Oil" refers to the maximum rate of production of oil in any area under consideration. There are different opinions when this point in time will be reached (or has been reached); but as FREIGHTVISION looks on a timeframe until 2050, there seems to be a high consensus that Peak Oil will be before then.

However, considering that a sustainable development should "ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987), the current transport is apparently not sustainable with regard to energy usage.

1.1.3 An Unsustainable Development with Regard to Road Fatalities

In 2007 Europe's road transport system caused 42,496 fatalities.[7] In addition 1,232,211 people were injured in road accidents (European Commission, 2010). Although very strong improvements in road safety have been reached in past decades,[8] further improvements are needed for a sustainable transport. The White Paper's (European Commission, 2001) goal to reduce the number of road fatalities by 50% between 2000 and 2010 will fail mainly due to the EU enlargement: EU-15 could reduce the number of road fatalities by 38.6% between 2000 and 2008, but EU-27 could reduce only by 31.1%.

1.1.4 An Unsustainable Development with Regard to Traffic Congestion

There are different numbers on the costs of road traffic/transport congestion varying between 0.5% and 1.5% of the GDP, which is generally considered as being too high.[9] Congestion is therefore a major economic sustainability aspect causing time losses, increased vehicle emissions, and as it has impacts on European competitiveness.

The objective of FREIGHTVISION was to provide policy recommendations for a sustainable development, focusing on these four sustainability criteria. The project should especially answer the following two questions:

6 Intergovernmental Panel on Climate Change.

7 All persons deceased within 30 days of the accident;

8 In 1990 there were 75.977 people killed (EU-27).

9 The congestion costs in Western Europe are estimated to be about 1% of the GDP. (UNITE 2003).

- What should be the politically agreed reduction targets for 2050 for these four sustainability criteria?
- What should be done by transport policy-makers to reach these targets?

The first question was answered by proposing a "Vision", and the second question was answered by proposing an "Action Plan". The "Vision" and the "Action Plan" were the two main project results.

1.2 Project's Objectives—Vision and Action Plan

1.2.1 Vision

The term "vision" can have many different meanings. Within this project, this term is used in two ways: a qualitative vision and a quantitative vision of a future European freight transport system.

The *qualitative vision* is displayed in Fig. 1.1. It was developed in one of the four FREIGHTVISION Forum Meetings together with the Forum participants. It visualizes the ideas and visions of the stakeholders about the future of the freight transport system and relevant economic aspects, like production and logistics processes. Like every brainstorming session, where many people are involved, the result is interesting but also very heterogeneous.

The qualitative vision was used as background information for the project.

The *quantitative vision* is a definition of reduction targets for each of the project's four sustainability criteria. These numbers (in percentage points) indicate which improvements—with regard to the four sustainability criteria of the project—should be targeted and thus agreed. Although called vision, these reduction goals should be both realistic and ambitious. It is important that this vision should be no utopia. It was a basic concept not to lose the ground under the feet and just define unrealistic goals.

The quantitative vision therefore describes a desirable, but realistic development path for the four criteria in focus for 2020, 2035, and 2050. The quantitative vision is meant, when in the further text the term "Vision" is used.

1.2.2 Action Plan

The action plan is a policy recommendation, on how the vision can be reached. It consists of bundles of actions both for transport and technology policy. Each action[10] contains research and technology development (RTD), transport policy aspects, and milestones for 2020, 2035 and 2050. The action plan is both robust and adaptive, as each action can be applied more or less strict and thus adapted in the future when additional information will be available.

10 For list of Actions see later chapters.

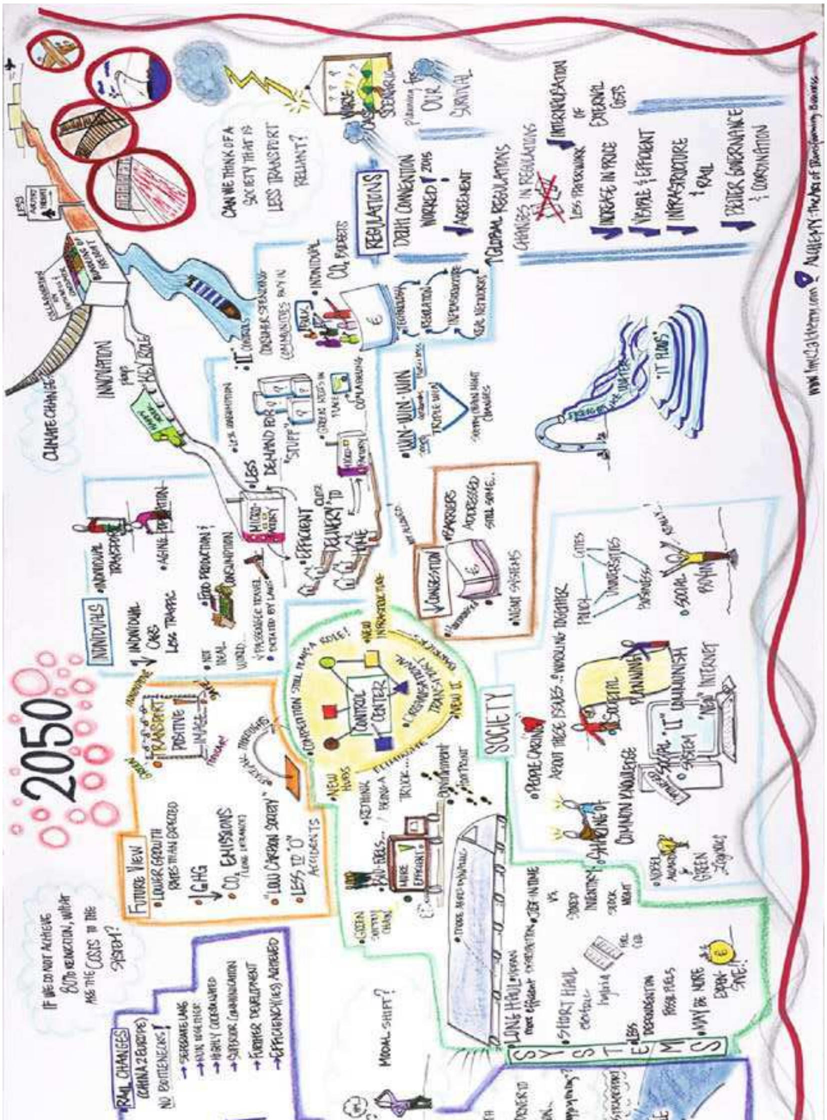

Fig. 1.1 Qualitative vision

1.3 Methodologies

There are two different major approaches for studies of the future: *modeling* and *participative processes*. Modeling is usually used for policy assessment with shorter time-horizons, while participative processes, like Delphi or FORESIGHT, are used for long-time horizons. In this project these two approaches, which in general are two different philosophies, were both sides depreciate the other methodology for their limitations, have been combined.

1.3.1 Modeling

On the one hand, the project team based its work on three models: TRANS-TOOLS[11] model was used for transport modeling, PRIMES[12] model for energy modeling, and the Finnish Environment Institute developed the SYKE-model within the project, which was used for modeling GHG emissions and fossil fuel share. These models were used for the trend analysis of the key drivers, and for the development of the forecasts and scenario.

1.3.2 Foresight

FORESIGHT is the preferred methodology for long-term policy making. As the subject is about developments until 2050, which definitely is a very long-time horizon for policy making, this methodology was also applied. The basic idea of FORESIGHT processes is not so much about predicting the future, but to get a common understanding amongst stakeholders about future developments and how this future could be shaped. This is done by establishing discussion rounds with stakeholders on predefined topics.

Within this participative process, different stakeholder groups create proposals to achieve sustainable freight transport, but due to their professional background, most of them address only part of the problem or focus on only one aspect of a solution. Following these advices would lead to sub-optimization and less-efficient proposals. As this project intended to take a holistic approach, where all aspects of the problem were addressed, i.e., infrastructure, ITS, propulsion systems, vehicles, fuels, interoperability etc. and all types of criteria in the solution: research, technologies, policies, and pricing, and these aspects should be biased, it was important to get a balanced number of participants from the different interest groups. Regarding the invitations,

11 TRANS-TOOLS is a transport modeling tool developed for the EC.

12 PRIMES is an energy model for Europe developed from the ICCS.

it was therefore paid special attention that all relevant areas were covered and that there also was no over- or underrepresentation of a certain stakeholder group or transport mode.

The participants[13] were personally invited and only invited experts were allowed to attend. In the project's FORESIGHT process more than 100 representatives participated from the EC, Member States' ministries, Advisory Councils, Technology Platforms & ERANET, freight forwarders and logistics companies, infrastructure operators, industry, trade, cargo owners, vehicle technology and energy suppliers, non-governmental organizations (NGOs), and trade unions.

There was a Forum Meeting every four months where the project's results were discussed together with the stakeholders. These Forum Meetings were mainly participative sessions, where stakeholders discussed specific questions, around tables with maximum 10 participants on each table, and under guidance of trained moderators. These four meetings took place in 2009 and 2010 and the results of the discussions provided input both for the project and for this book.

In Fig. 1.2 it can be seen how the integration between the two methodologies, modeling and FORESIGHT, took place. Modeling was done in the following project steps: (1) key drivers—policy, technology and mega trends; (2) forecasts and preliminary vision; (3) actions, scenario, and wild cards; and (4) vision and action plan. The FORESIGHT Forum Meetings took place after each project step.

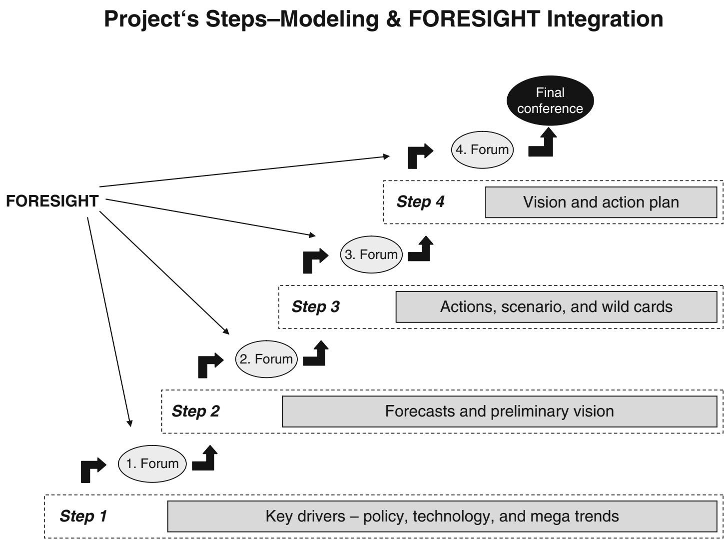

Fig. 1.2 Project's steps—integration of the modeling and FORESIGHT process

13 The list of participants can be found in the Appendix.

Figure 1.2 also shows the project's four steps:

- The key drivers (policy, technology, and mega-trends) of the European freight transport system were analyzed.
- Based on the key drivers' trends, Business-as-usual (BAU) forecasts for each sustainability criterion were developed, and a preliminary vision (i.e. reduction targets for the four sustainability criteria) was defined.
- Policy actions both from transport and RTD were evaluated, with regard to the sustainability criteria; a scenario was developed, on how the vision can be reached; and wild cards, low-likelihood, high impact, and hard-to-predict events, were identified.
- Finally, an action plan was developed by integrating policy actions into the scenario, and the vision was defined.

All these project's steps were based on the conceptual framework, which is described in the following section.

1.4 Conceptual Framework

The conceptual framework (see Fig. 1.3) defines the methodological approach for the FREIGHTVISION project and provides a structure of the main system components and the interrelationships between these components.

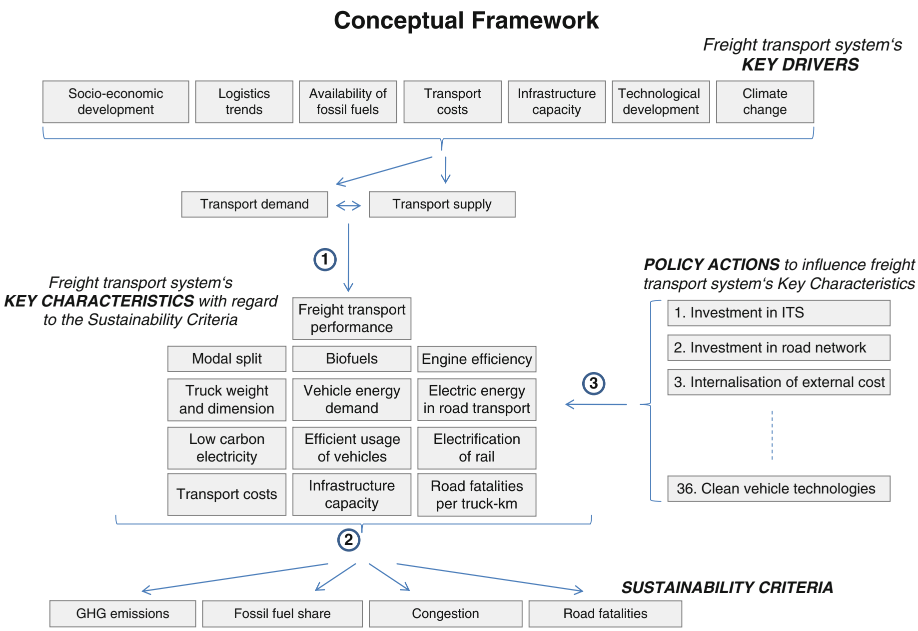

Fig. 1.3 Conceptual framework

FREIGHTVISION's conceptual framework consists of the following four components: key drivers, key characteristics, policy actions, and sustainability criteria.

- *Key drivers—freight transport system's key drivers.* These are the key influencing factors that trigger and change the transport system. They contain both external factors like socio-economic development and internal factors like transport cost.
- *Key characteristics—freight transport system's key characteristics with regard to the sustainability criteria*. Key characteristics describe the status of the transport system.[14] If the key characteristics are known, then the transport system is sufficiently described for a certain task. Different tasks might demand different key characteristics.

FREIGHTVISION'S objective was to estimate the status and development of the four sustainability criteria; and therefore one of the challenges of the project was to identify the key characteristics, with regard to the four sustainability criteria.

The following key characteristics describe the status of the transport system sufficiently for the project's task:

  - Freight transport performance: total tkm[15] of road, rail, and IWW;
  - Modal split: tkm split between road, rail, and IWW;
  - Biofuels: upstream emissions in producing biofuels and the share of biofuels;
  - Engine efficiency: the efficiency of the engines used in road, rail, and IWW;
  - Truck weight and dimension: transport performance split between different truck types;
  - Vehicle energy demand: MJ needed to move 1 tkm;
  - Electric energy in road transport: primary energy input for trucks;
  - Low-carbon electricity: upstream emissions in producing electricity;
  - Efficient usage of vehicles: road, rail, and IWW transport efficiency that is not covered in vehicle or engine efficiency. It covers aspects like loading factors, empty runs, driver behavior, etc.;
  - Electrification of rail: percentage of rail tkm transported with electric engines;
  - Transport costs: price per vhkm;
  - Infrastructure capacity: vehicle throughput on road network;
  - Road fatalities per truck-km;

- *Policy actions—policy actions to influence freight transport system's key characteristics.* These are transport and RTD policy actions. These are the options transport policy-makers have. Within the project, 36 policy actions were identified.
- *Sustainability criteria*. These are the four sustainability criteria—GHG emissions, fossil fuel share, traffic congestion, and road fatalities.

14 The methodological difference between Key Drivers and Key Characteristics is the following: Key Drivers are the triggers for changes of the transport system, whereas Key Characteristics describe the status of the transport system.

15 Tonne km.

The arrows in Fig. 1.3 show the linkages between the system components. Three linkages are relevant.

- *The impact of the key drivers on the key characteristics* (via transport demand and transport supply). This linkage is marked with the number “1” in the figure.
- *The impact of the key characteristics on the sustainability criteria.* This linkage is marked with the number “2” in the figure.
- *The impact of policy actions on the key characteristics.* This linkage is marked with the number “3” in the figure.

The vision, forecast, scenario, and action plan are based on the components and linkages of the conceptual framework.

- *VISION*: The vision is a definition of targets for each of the four sustainability criteria to be reached by 2020, 2035, and 2050.
- *FORECAST*: In the forecast, the development of the sustainability criteria was modeled. This was done by assuming: how the key drivers will develop and derive from this development, and how the key characteristics of the transport system will evolve (link 1). Based on these key characteristics, the development of the sustainability criteria was calculated (link 2).
- *SCENARIO:* The goal of the scenario development was to find a way, where both the vision is reached and a realistic development of the key drivers is taken into account. This was done using a “*BACKCASTING*” approach: the starting point was the vision, i.e., the targets defined for the sustainability criteria. Based on these numbers, a certain development of the key characteristics was calculated (link 2), which is also realistic with regard to the development of the key drivers (link 1). The scenario is therefore a certain composition of the key characteristics, where the vision is reached and the development of the key drivers is not neglected.
- *ACTION PLAN:* The goal of the action plan was to find a bundle of policy actions, where the scenario, i.e., a certain composition of key characteristics, is reached. This analysis was done for each key characteristic separately, i.e., the action plan consists of a bundle of actions and tasks for each key characteristic (link 3) and answers the following question: Which bundle of policy actions is most effective to reach the status of each key characteristic defined in the scenario?

These system components of FREIGHTVISION and their results are presented in the following chapters of this book.

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Part II
Methods

2 Foresight Process

Stephan Helmreich, Doris Wilhelmer, Klaus Kubeczko, Julia Düh, and Helena Kyster-Hansen

Abstract In Foresight processes both experts and decision-makers from policy, industry, research, and civil society are brought together to create channels for communication and to develop a basis for shaping the future. The Foresight methodology was the guideline for the whole project and each individual methodology, like modeling, forecasting, backcasting, or literature review, was considered as part of the whole Foresight process. This chapter introduces the objective of Foresight processes and explains the techniques used within FREIGHTVISION.

2.1 Introduction

In Foresight processes both experts and decision-makers from policy, industry, research, and civil society are brought together to create channels for communication and to develop a basis for shaping the future. Foresight processes support policy-making, by reaching a deeper understanding and shared knowledge of policy-makers and stakeholders about the impact factors, drivers, and the dynamics influencing the long-term future, and by getting stronger support by stakeholders. The outcomes of Foresight processes can be split into formal and informal outcomes.

- Formal outcomes: Scenarios, technology roadmaps, action plans, Delphi studies, visions, interim, and final reports;
- Informal outcomes:
  - Mutual learning of relevant stakeholders based on strategic forward-looking dialogue processes, where technology and innovation are linked to wider socio-economic issues.
  - Coordinated actions and stakeholders' support of the formal outcomes of the Foresight process.

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2.1.1.1 Foresight Techniques

There exists a wide range of Foresight techniques and often they are combined in different ways. In most cases the methodological framework of Foresight is tailored to the specific needs of the Foresight process as well as to the allocation of resources (e.g., people, expertise, technology, or time). Figure 2.1 gives an overview about various Foresight techniques, grouped according to four categories: expertise, evidence, creativity, and interaction:

- *Expertise-based techniques* are based on the knowledge of experts in a particular area. FREIGHTVISION's Foresight process integrated experts from many different areas and applied the following expertise-based techniques: roadmapping, backcasting, quantitative scenarios/forecasts, expert panels, interviews.
- *Interaction-based techniques* are based on the interaction of stakeholders. FREIGHTVISION's Foresight process was based on four conferences/workshops called "FREIGHTVISION Forum Meetings," where in addition to discussions, also brainstorming and voting/polling techniques were applied.
- *Evidence-based techniques* served as a starting point for the other Foresight techniques used in FREIGHTVISION's Foresight process. Especially modeling and

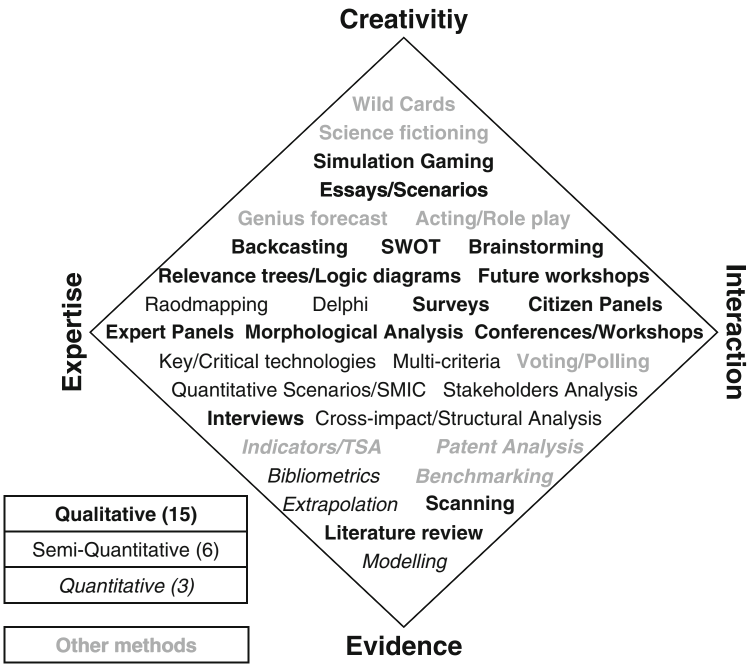

Fig. 2.1 Categories of Foresight methods. Adapted from (Popper, 2008)

literature review were used by the project team as a basis for the deliverables and management summaries, and thus for the Forum Meetings.
- *Creativity-based techniques* make use of the creativity of the stakeholders. FREIGHTVISION's Foresight process made use of the following techniques: wild cards, mind map/painting and qualitative scenario writing.

In FREIGHTVISION's Foresight process, the techniques from these four categories were well balanced, which is seen as a critical success factor of participative Foresight processes. The approach, objective, results, and the project context of each of the techniques applied are described in the next section.

2.1.1.2 Organizational Development

Foresight is far from being a "self-executing" process. Such complex processes of change and transformation make it essential to combine Foresight methodology with principles and interventions from organizational development, for both observing and intervening. In particular the clear description and negotiation of different roles and tasks supports effectiveness and intensity of stakeholder dialogues and foster the quality of formal outcomes.

Organizational development focus is on

- the targets of the overall process,
- the targets of the single steps, and
- all actors concerned.

Organizational development aims to coordinate communication between all actors, in order to allow new insights and effective transformation processes. This is done

- *by generating a specific architecture*: FREIGHTVISION's architecture (see Fig. 2.2) consisted of
  - Contractor: DG TREN
  - Project Management (PM): AustriaTech
  - Foresight Expertise/Organizational Development Team (FE/OD Team): Austrian Institute of Technology, AustriaTech, and TetraPlan.
  - Project Team: FREIGHTVISION's Project Consortium
  - Stakeholder Board: FREIGHTVISION Forum Members
- *by designing events:* FREIGHTVISION's events were the Pre-Forum Meeting, Forum Meeting, and Post-Forum Meeting. At these meetings, organizational development formats such us world café, result galleries, and delegation conferences were used to enable open discussions as well as gathering up highlights and results within large groups.

In a later section the events and formats used within FREIGHTVISION are described, but not the social-related processes.

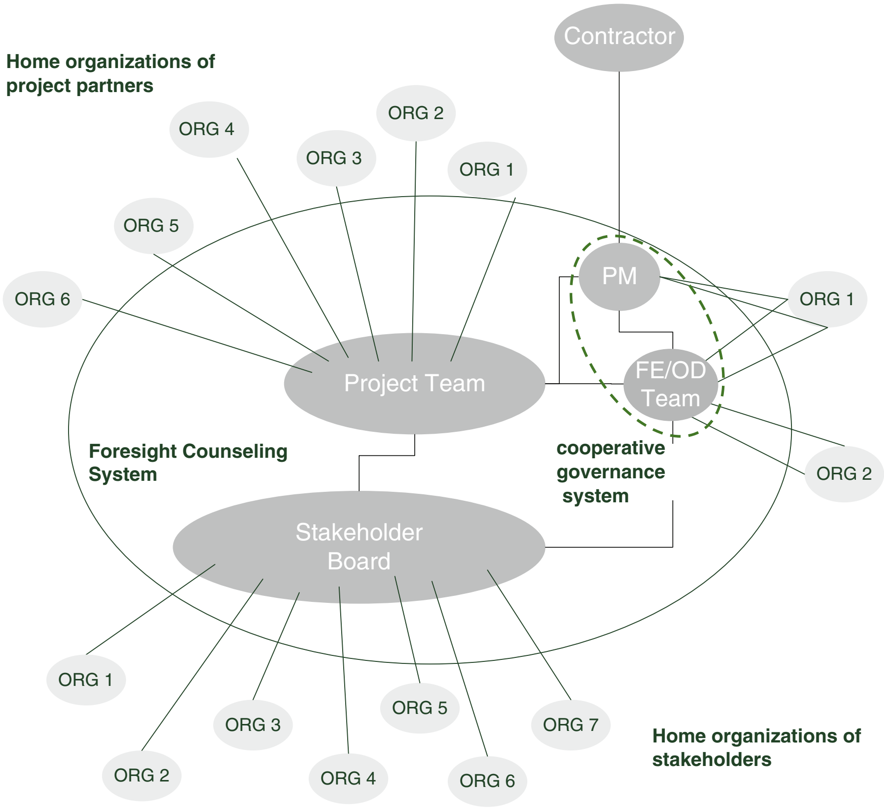

Fig. 2.2 FREIGHTVISION's architecture

2.2 FREIGHTVISION's Foresight Process

2.2.1 Introduction

The aim of FREIGHVISION was to develop a long-term vision, as well as an action plan, for both freight transport and Research and Technology Development (RTD) policy. The steps necessary to develop the vision and action plan were

- *Analysis of the key drivers of the freight transport system*
- *Forecast of the development of the sustainability criteria and preliminary vision*
- *Identification of actions, development of a scenario, and brainstorming about wild cards*
- *Definition of the vision and the action plan*

Stakeholders were involved in all steps of the project. Every four months there was a Forum Meeting organized, where all stakeholders were invited to reflect on the

intermediate results and to discuss future directions. In this section the Foresight process will be introduced by describing the selection of the stakeholders, the communication outside of the Forum Meetings, the Foresight techniques, and the organizational development techniques used.

2.2.2 Forum Members

The first precondition for a Foresight process is to get the "right" people to attend. Who the right people are, depends on the project's goal. For FREIGHTVISION the goal was defined in the project's description as to "Develop a long-term vision and a robust and adaptive action plan both for transport and technology policy for a sustainable long-distance freight transport, which *are supported as much as possible by the relevant stakeholders*." Therefore the objective was to get the "relevant stakeholders" to attend.

When the project proposal was submitted, the concept was to have representatives from the organizations as described in Fig. 2.3.

The organizations are as follows:

- The advisory councils should bring in their expertise on research and technology development:
  - ERTRAC—European Road Transport Research Advisory Council

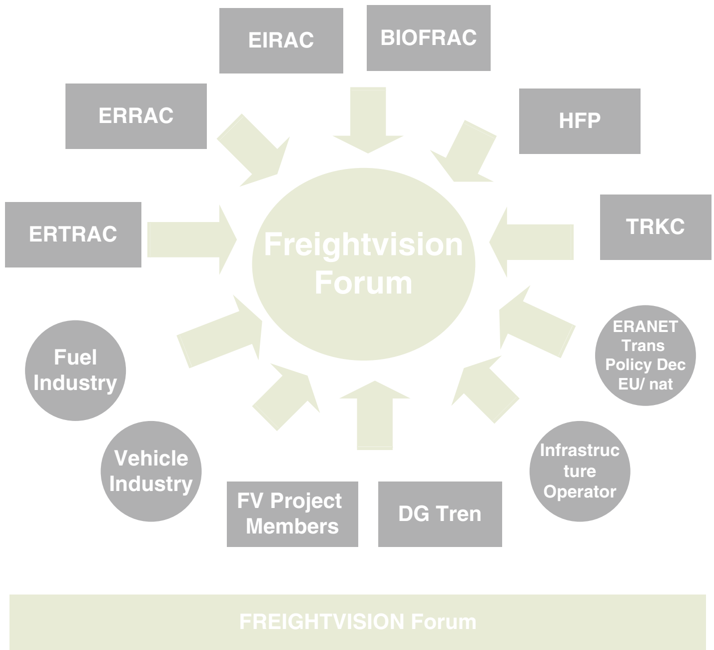

Fig. 2.3 Original forum concept

  - ERRAC—European Rail Research Advisory Council
  - EIRAC—European Intermodal Research Advisory Council
  - BIOFRAC—European Biofuels Research Advisory Council
  - HFP—European Hydrogen and Fuel Cell Technology Platform
- By integrating the TRKC—Transport Research Knowledge Centre—knowledge from passed European Commission Framework Programme projects should be brought in.
- ERA-NET (European Research Arena) should contribute by bringing in their knowledge about Member States' research activities. The most relevant ERA-NET with regard to FREIGHTVISION was ERA-NET Transport.
- As not only lobbyists from Brussels should attend, the concept was also to invite company representatives from the vehicle industry, infrastructure operators, and fuel industry.
- Finally, representatives from the European Commission Directorate General Energy and Transport should attend.

At that point of time it was planned to have about 30 attendants plus the project team at each Forum Meeting.

When the project started, the project team reconsidered the concept and decided to try to get a broader Forum and to target a size of about 100 people. It was structured according to Table 2.1. For each category it was defined, how many people should attend (target number).

The project team put in large efforts in finding the best suitable stakeholders within the different categories and each selected people got a personal mail, asking for their participation in the four Forum Meetings. This was a time-consuming part of the project, but the core project team believed that this was vital for the success of the project. In this manner some 150 stakeholders were contacted before the first Forum Meeting, before the final numbers of 75 participants were in place. Some never answered, despite several reminders; some didn't find the time to participate; and some didn't see their role as stakeholder in the project.

In Appendix B the list of stakeholders is listed and also which Forum Meeting each of them attended. Some of the stakeholders represent different of the above-mentioned organizations (e.g., industry sector and advisory council), but what can be seen from this list is that nearly all organizations were well represented. The only important organization, which was not represented at all, was the European Parliament.

The total number of attendants at the four Forum Meetings is shown in Table 2.2.

It was considered as one of the greatest risks of the stakeholder integration that the number of attendants would go down during the project period. Therefore it was a success of the project that the number of attendants did not go substantially down and that in all four Forum Meetings each organization was well represented.

Another aspect here was that many of the stakeholders are very busy and it was not easy for them to fit in all the four Forum Meetings in their calendars, especially as some of the Forum Meetings collided with other important meetings, e.g., Parliamentary week in Strasbourg. In such cases, many of the stakeholders did their best to find

Table 2.1 Stakeholder target list

Organization		Target number
European Parliament		7
European Commission		10
Advisory councils	Road	3
	Rail	2
	Waterborn	2
	Intermodal	2
	Fuel	2
ERA-NET		4
Freight forward and logistics companies	Focus on rail	3
	Focus on ship	2
	Focus on road	4
	Focus on air	1
	Focus on intermodal	2
Infrastructure operators	Rail	3
	Road	3
	Ports and IWW	2
	Airports	1
	Intermodal terminals	2
Industry and trade, cargo owners	Automotive	1
	Chemicals and oil products	1
	Foodstuff and agriculture	1
	Forestry, paper, and pulp	1
	Iron, steel, and metal	1
	Other industry and trade	3
Vehicle and technology supply industry	Propulsion systems	2
	Rail industry	2
	Vehicle industry	3
	Energy supply	2
Science (University, etc.)		5
Environmental organizations		3
Trade unions		2
	sum	**82**

Table 2.2 Number of attendants at the four Forum Meetings

	Stakeholders	Project partners	Total
Forum 1	75	25	100
Forum 2	65	25	90
Forum 3	60	20	80
Forum 4	60	20	80

another representative from their organization that could participate. It was also very interesting to see that in the middle of the project period, the interest from outside had grown, and there were new stakeholders asking to participate as they had heard about the interesting methods and project development.

2.2.3 Communication Outside of the Forum

As preparation for each Forum Meeting, a management summary (AustriaTech, 2009a, 2009b, 2009c, 2010) was developed and sent to the forum attendants about 2 weeks before the specific Forum Meeting. This was done for the stakeholders to prepare for the Forum Meetings. The management summaries contained the following:

- The results of the project team since the preceding Forum Meeting
- The results of the preceding Forum Meeting
- The feedback received by the Forum participants. (The Forum participants were invited to send their comments and critics to the project team to be published in the management summary.)

The management summaries, which were 30–80 pages long, were the main medium of communication both within the project team and to the stakeholders. Although the preparation of the management summaries was very time consuming, it was very valuable because of the following aspects:

- Each project team member was very visible with its input. The author's name was written under each section. This led to a high identification and responsibility with the texts.
- Due to the limited space the authors were forced to focus on their main results. Very often the problem of projects is that too long reports are produced, which are not read being time consuming.
- The stakeholders were able to prepare for the Forum Meeting. (At the Forum Meetings, no additional content was presented.)
- As the Forum results were presented in the management summary, it was visible that the results of the discussions were used by the project team. This is one of the biggest difficulties in such a project, how to assure that the results of the discussions are used by the project team and also how this usage can be made visible to the stakeholders.
- The stakeholders could use the management summaries as a platform for their comments as their input was printed as "readers' comments."

There were also many possibilities for the stakeholders to contact the project team throughout the project period, and this was also something they actively did. After each Forum Meeting the participating stakeholders got a personal e-mail from the task leader, thanking for their participation and in many cases also with some personal reflections that the specific stakeholder had been discussing. This lead to a

two-way communication between the task leader and the stakeholders, and many of the comments deriving from this were also brought further onto the remaining project team, and into the on-going work in the project.

This was done throughout the project period, and a large number of the stakeholders utilized the possibility to give further comments to the Management Summaries and to the project work as a whole. In this manner also, the stakeholders seemed to get a closer connection with the project, which was a good base for the success of the project.

Sending personal mails to each of the stakeholders is a very time-consuming task, and the time used for this should not be underestimated. However, the results speak for themselves, as we managed to keep up the high number of interested stakeholders throughout the project period. In some cases, the stakeholders sent their comments to the Management Summaries, for the project team to include them, despite that the stakeholder didn't have the possibility to participate. This shows that a large number of the stakeholders saw their role in the project as important.

The project team also tried to use interactive Web communication by installing a discussion Forum at the project's Web site, but this instrument was not used at all.

2.2.4 Foresight Techniques Applied in FREIGHTVISION

Within the FREIGHTVISION process, the following Foresight techniques were used.

2.2.4.1 Modeling

- *Approach*: In the project three models were used—TRANS-TOOLS, the SYKE-model, and PRIMES. TRANS-TOOLS and the SYKE-model were used throughout the whole project, whereas PRIMES was used only in the first phase of the project (External factors). TRANS-TOOLS model was mainly used for congestion modeling on the European road transport network. The SYKE-model was used for GHG emissions and fossil fuel share modeling. PRIMES model was used for energy modeling. Modeling was done by the project team. The assumptions and the results of the modeling were presented to the stakeholders. Due to the complexity (and black-box concept) of the models, stakeholders could only take note of the assumptions and the results, but could not discuss the models.
- *Objective*: Modeling results for energy prices (PRIMES), congestion forecast and scenario until 2035 (TRANS-TOOLS), and GHG emissions forecast and scenario until 2050 (SYKE model).
- *Result*: The results of the modeling are presented in later chapters of this book.
- *Project context*: Modeling was used for the forecasting and backcasting/scenario development.

2.2.4.2 Discussion on Key Drivers

- *Approach:* In the first Forum Meeting, key drivers for European long-distance freight transport were discussed. These discussions were done in world café dialogue

rounds,[1] where stakeholders discussed with project partners their analysis. At each table one of the following areas was discussed:

  - European policy
  - National policies
  - Key demonstration projects and intermodality
  - Infrastructure technologies and ITS
  - Logistics technologies<<incorrect tags for list>>
  - Engine technologies
  - Socio-economic trends
  - Logistics trends
  - Transport demand and congestion
  - Emissions

- *Objective:* The objective of the discussions was to get a feedback on the project team's work to improve the achievement and thus to
  - identify the most important external and internal key drivers of each area and
  - how these key drivers influence these areas up to 2050.
- *Result:* The results of the discussions were summarized, printed in the following management summary and used as an input for the respective deliverables. The summaries of the discussions are listed in Appendix D.
- *Project context:* In the first project phase, the project team tried to identify the most relevant key drivers of long-distance freight transport and estimate the trend development. This discussion was supposed to provide a feedback to the project team to improve their analysis.

2.2.4.3 Storyline Development

- *Approach:* In the first Forum Meeting, storylines were developed. Storylines were defined as a chain of arguments, where key drivers from different areas are combined. These hypothetical combinations (related to the project's sustainability criteria: GHG emissions, fossil fuel share, congestion, road fatalities) have an impact on freight transport.
- *Objective:* The objective was to develop storylines for each of the following futures:
  - Low GHG emission future
  - Low fossil fuel share future
  - Low congestion future
  - Low road fatalities future
  - Trend GHG emission future
  - Trend fossil fuel share future
  - Trend congestion future
  - Trend road fatalities future

1 "World cafe<<é>> dialogue round" is an organizational development technique described in the next section.

  - High GHG emission future
  - High fossil fuel share future
  - High congestion future
  - High road fatalities future
- *Result:* The results of the storyline development are listed in Appendix E.
- *Project context:* In the second step of the project, the project team developed high trend and low business-as-usual forecasts for the four project's sustainability criteria. The storyline development was done before the development of the forecasts and should help the project team to develop consistent forecasts.

2.2.4.4 Mind-Map/Painting

- *Approach*: At the second Forum Meeting, a "Vision" painting was developed in co-operation with a professional drawer. First the participants were split into world café dialogue groups, where they should imagine living in a desirable future in 2050 and describe, how this future looks like:
  - What was achieved? What is special about these achievements?
  - What are the differences in the stakeholders' special area?
  - What is surprising?
- Then the ideas were collected and drawn into one picture, the vision painting.
- *Objective*: The objective was to develop a joint vision painting about freight transport in 2050 and by visualizing these ideas to exchange these visions and stimulate creative thinking.
- *Result*: Vision painting. See Appendix F
- *Project context*: This technique was used in the second Forum, after the BAU forecasts and the preliminary quantitative vision was presented. This procedure should bring in visionary ideas as a contrast to the "realistic" forecast and preliminary vision.

2.2.4.5 Portfolio Analysis

- *Approach*: At the second Forum Meeting after the development of the Vision Painting, a portfolio analysis was done, to close the gap between 2050 and the present. The stakeholders, coming from different areas like infrastructure operators, logistics and transport companies, cargo owners, and vehicle and energy suppliers thought about their opportunities to contribute to a sustainable transport system. Each world café table had one participant from each professional background and each world café discussed:
  - *Which actions did we take until 2045/2025*?
  - *Which actions were successful*?
- As a starting point 60 actions were listed in the management summary, where the stakeholders could select from or add additional ones.

  Finally the actions were benchmarked by performing a portfolio analysis (Fig. 2.4). Like in the classical portfolio analysis, the *x*-axis indicates an absolute number,

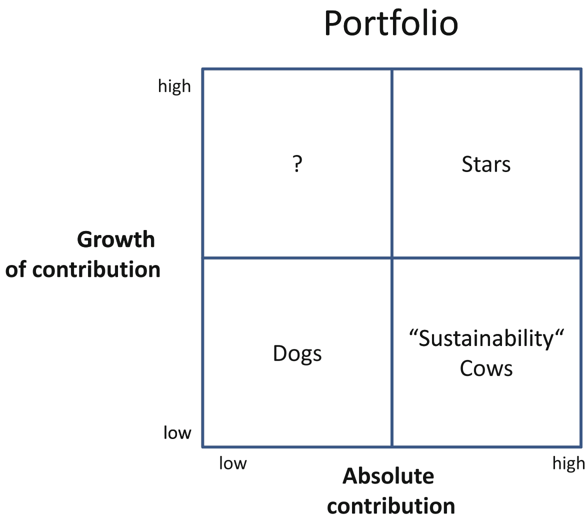

Fig. 2.4 Portfolio

whereas the *y*-axis indicates a growth number. In contrast to the contribution to a business criterion like profit, in this case the indicator was a sustainability criterion. By this approach the actions with

- *the highest absolute contribution and*
- *the highest growth rate*

for reaching a certain sustainability criterion were identified. For each sustainability criterion (GHG emissions, fossil fuel share, congestion, and road fatalities), a separate portfolio analysis was done. There were two rounds: one for 2025 and one for 2045.

- *Objective*: The goal was to identify the most promising actions in the medium and long run with regard to the four sustainable criteria.
- *Result*: 18 portfolios for each sustainability criterion were developed. Half of them for 2025 and half of them for 2045; see Appendix G.
- *Project context*: This technique was used in the second Forum. In the next project step, the project team developed a complete list of opportunities and actions. By this analysis, it was avoided that a promising action would be left out.

2.2.4.6 Brainstorming Wild Cards

- *Approach:* At the third Forum Meeting, the robustness of the scenario was checked by a wild card-brainstorming session. Three different perspectives were taken:
  - Wild cards: Which low-likelihood, high-impact, and hard-to-predict events influence the scenario?
  - Paradox: What can I do to assure that the scenario will fail?
  - Positive: What can I do to assure that the scenario will come true?

- *Objective:* To identify the weak points of the scenario
- *Result:* 52 wild cards, 22 paradox, and 16 positive; see Appendix H
- *Project context:* This technique was applied in the third Forum as a quality assurance mechanism. It was done when the first draft of the scenario was presented, and it assured that there are no major risks neglected by the project team.

2.2.4.7 Forecasting

- *Approach:* Business-as-usual (BAU) forecasts for the development of the four sustainability criteria until 2050 were developed. These forecasts were based on the SYKE-model and TRANS-TOOLS. Three forecasts, a low-, trend-, and high-forecast were developed for each sustainability criterion to show the range of future development. The trend forecast indicates the most likely development, whereas the low indicates a lower limit and high forecasts an upper limit for future development.
- *Objective:* To get an impression about future developments, if there will be no behavioral change of the private or public sector. The size of the gap between the low and high forecast should also give an indication about the likeliness of the trends forecast.
- *Result:* Forecasts are presented in Chap. 7
- *Project context:* This was a major task in project step 2 and a basis for the scenario development.

2.2.4.8 Backcasting

- *Approach:* Backcasting for the development of the four sustainability criteria was based on the SYKE-model and TRANS-TOOLS. The starting points were 2050 and the quantitative targets defined in the vision for the four sustainability criteria. As a next step it was assumed how the models' input parameters (transport system's Key Characteristics) would have to develop until 2050 for the targets to be reached. The same was done in a second step for 2035 and in a third step for 2020.
- *Objective:* To develop a realistic scenario on how the vision can be reached.
- *Result: The scenario is described in* Chap. 8.
- *Project context: This was a major task in project step 3 and basis for the action plan.*

2.2.5 Organizational Development—FREIGHTVISION's Events and Formats

2.2.5.1 Events —Internal Presentation/Pre-Forum Meeting/ Forum Meeting/Post-Forum Meeting

Each Forum Meeting lasted 3 days.

- *Internal presentation:* On the first day, all presentations were in front of the whole project team, and each project team member could give feedback. By this approach,

inconsistencies between the presentations and eventual mistakes could be avoided. In addition to the schedule, the roles and the methodologies of the Forum Meeting were explained to the project team.

- *Pre-Forum Meeting:* In the late afternoon of the first day, a "Pre-Forum" took place. It started with a presentation by an external speaker, who was neither member of the project team nor a Forum participant. These talks introduced into the topic of the Forum (see Appendix F):
  - First Pre-Forum
    - Topic: Foresight
    - Speaker: Ian Miles, Manchester University
  - Second Pre-Forum
    - Topic: Costs of Climate Mitigation and Impacts of Economic Crises
    - Speakers: Jens Borken-Kleefeld, IIASA; Werner Rothengatter, Karlsruhe Institute of Technology
  - Third Pre-Forum
    - Topic: North America and Climate Mitigation in Transport
    - Speakers: Berry E. Prentice, University of Manitoba; Jeannie Beckett, The Beckett Group
  - Fourth Pre-Forum
    - Topic: Copenhagen Process
    - Speakers: Klaus Radunsky, Umweltbundesamt, AT; Mark Major, EC-DG ENV
- After the presentations and discussions, a social event took place to increase the communication and networking of the stakeholders. Another objective of the Pre-Forum was that the Forum participants would arrive the day before the Forum and thus it should be avoided that attendants come late to the Forum Meeting next day.
- *Forum Meeting:* The Forum started at 9 a.m. and ended between 5 and 6 p.m. Most of the time was dedicated to interactive session. Very few presentations were held. Each presentation did not take more than 10 min, and its main purpose was to be an impulse for the consecutive interactive sessions. The content of the presentations was identical to the content of the Management Summaries. Each Forum consisted of the following parts:
  - Welcome and "Introduction of New Stakeholders" session (description below).
  - Achievements since the preceding forum: presentations and interactive sessions to provide feedback to the project team. This session ended before lunch.
  - Inputs for the succeeding project phase: interactive sessions
  - Outlook on next project step and social event

The agendas of the four Forum Meetings can be found in Appendix C.

- *Post-Forum Meeting:* On the day after the Forum, the project team came together to discuss the results of the Forum and what there could be used by the project

team. This meeting started with a "Lessons Learned Session," where the project team members "brainstormed" what was surprising at the Forum—both from the contents discussed and from the process (e.g., stakeholder involvement, roles, success of methods). After this "Lessons Learned Session," the project team discussed which input would be used for improving past work and what could be used for future work packages.

2.2.5.2 Formats

- *Introduction of new stakeholders:* Each Forum Meeting started with an "Introduction of New Stakeholders" session. In this session new and old stakeholders were brought together to enhance learning from each other. The new stakeholders explained why they attended and the old stakeholders explained what had happened in the preceding Forum Meetings. The objective of this session was to integrate new stakeholders quickly from both an emotional and a know-how perspective.
- *World café dialogue group:* The "World Café" method was developed by David Brown and Juanita Brown (Brown and Isaaks, 2005) as a methodology of organizational learning (MIT/ Peter Senge). It targets to go beyond habitual perspectives and statements. This is enhanced by a special kind of formulating "dialogue questions" addressed to little groups and by repeating dialogue-round on the same question realized by newly mixed up dialogue partners. Two to three dialogue rounds on the same topic allow new combinations of arguments to the same question and thus to go beyond traditional perspectives and results. One group comprises 6–8 participants sitting at a (round) table and discussing a predefined topic. One person has the role of a host; the others have the role of a dialogue partner. The host encourages people to speak, write, and draw key insights on a paper-table-cloth, and briefly share key insights from the prior conversations to enable the others to link and use ideas. The host remains at the table while participants change table and dialogue partner within each round. The dialogue partner listens and contributes actively to the discussion. This methodology was applied successfully many times throughout the four Forum Meetings.
- *Delegates' conference:* The "Delegates' Conference" is a moderated discussion. It consists of an inner and outer circle. In the inner circle 6–12 people are sitting in a circle without a table. The other Forum Members are part of the outer circle. Only the people of the inner circle discuss with a microphone. If someone from the outer circle wants to contribute to the discussion, he has to use the "open chair." The open chair is a seat in the inner circle which is not used. The contributor from the outer circle can sit down on the open chair to raise his question, but has to leave afterward. In the inner circle, two microphones are handed over to the people who want to speak. One or two persons in the inner circle have the role of a moderator. In the outer circle one person has the role to document the contributions on a flip chart.
- *Gallery:* The results of world café dialogue groups are summarized either on DIN A4 papers or on flip charts. When these documentations are fixed on surrounding

walls to make them readable to the other participants, it is called a gallery. This technique was used successfully at a number of sessions, for the stakeholders to also take part in the discussions at other world café tables than those they had attended themselves. The stakeholders gave additional inputs and comments to the results brought forward.

- *Voting:* At the fourth Forum Meeting, a public voting was done. Each participant stood on an imaginary line, where one end marked a high agreement and the other end a high disagreement to the project results. By choosing the position on the imaginary line, the participant demonstrated his/her rate of agreement to the vision and action plan, which were presented. Participants were asked to tell their motives, why they chose a specific place.

2.3 Conclusion and Outlook

The official name of the FREIGHTVISION project was "FREIGHTVISION—Freight Transport Foresight 2050." It was intended to mention the "Foresight" methodology in the title and thus give it such a prominent role, because this methodology was the guideline for the whole project. Each individual methodology like modeling, forecasting, backcasting, or literature review was considered as part of the whole Foresight process.

One of the FREIGHTVISION's main challenges was the design of this Foresight process, i.e., to select the right technique for a specific task and to assure that the techniques fit together. In addition, from an organizational development perspective, it was necessary to assure that the spirit and vision of the core team was passed to the whole project team and to all Forum members.

This approach was supported by the project team's communications with participating stakeholders between the Forum Meetings via phone, letters, or email.

This chapter does not include the results of the Foresight process as the results are found in all the consecutive chapters.

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3 Developing a Model for Long-Distance Freight Emissions and Energy Consumption

Tuomas Mattila and Riina Antikainen

Abstract The FORESIGHT process required many quantitative estimates, which were not available for long-distance freight transport. Current emission inventories, impacts of forecasts, and previously published scenarios report usually total transport emissions, without focusing specifically on long-distance freight. Since detailed statistics were unavailable, a quantitative model was developed to estimate the figures from existing data. The model was used to estimate the emissions and energy consumption of future transport systems described in the business-as-usual forecasts and in the backcasts. This chapter describes the model structure and parameterization, with an emphasis on the use of the model to estimate the current status of the freight transport system in 2005.

3.1 Model Structure and Opportunities for Analysis

The focus of the model was on greenhouse gas emissions and energy consumption, but other emission categories could be included, if necessary. Instead of creating a forecast tool based on simulation, another kind of approach was used. The developed model is an analysis framework, which aggregates bottom-up data into an estimate of the emissions and energy consumption of the whole freight transport system. As an analysis framework, the model does not contain any data, but relies on external input scenarios.

The model was constructed as a series of linear transformations, starting from emissions and energy demand of fuels and aggregating the results first into engine types, then vehicles, modes, and finally overall transport (Fig. 3.1). In principle, the developed model should be able to estimate the emissions not only of the current transport system, but also that of different future scenarios. Future long-distance freight fleets can have a range of vehicles, with different energy demands and engine combinations as well as fuel mixes (for example both hybrid vans running on biodiesel and large trucks running on natural gas and diesel mixtures). In order to capture all the possible combinations, a linear algebra (matrix computation) approach was used. Using matrix equations

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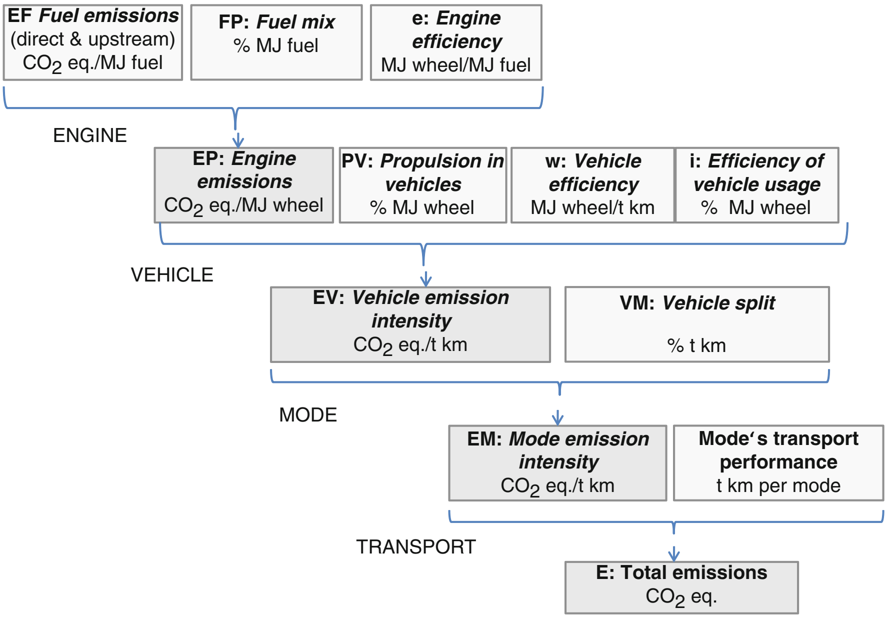

Fig. 3.1 The structure of the emission and energy model. The model proceeds from bottom to up, aggregating technology-level results into an overall emission and energy inventory of different modes and the whole transport system. (Adapted from Helmreich, 2010)

allowed changing system configurations without increasing model complexity, since the equations remained the same irrespective of the amount of vehicle–technology–fuel combinations. Details of the model components are given below.

First, emissions and energy demand of different fuels were aggregated to engine types through fuel mix and engine efficiencies:

$$\mathbf{EP} = \mathbf{EF} \cdot \mathbf{FP} \cdot \hat{\mathbf{e}}^{-1} \tag{3.1}$$

where **EP** = emissions from megajoules (MJ) of energy to wheel in propulsion technologies
($n \times p$ matrix, where n is the amount of indicators, and p is the amount of propulsion technologies considered)
EF = emissions from production, distribution, and use of a MJ of fuel type ($n \times f$ matrix, where f is the amount of fuel types considered)
FP = fuels used to supply the energy required by propulsion technologies (MJ/MJ) ($f \times p$ matrix)
$\hat{\mathbf{e}}$ = a diagonal matrix of the fuel efficiencies **e**, i.e., work performed for energy required (MJ_{wheel}/MJ_{tank})($p \times p$ matrix)

These emissions and energy demands were then weighted with the use of propulsion technologies in various vehicles and with the work requirements of transporting goods with a given vehicle, to give the emissions for different vehicle types **EV**:

$$\mathbf{EV} = \mathbf{EP} \cdot \mathbf{PV} \cdot (\mathbf{I} + \hat{\mathbf{i}}) \cdot \hat{w} \tag{3.2}$$

where **EV**= emissions from transporting 1 tkm of goods with a given vehicle ($n \times v$ matrix, where v is the no. of vehicles considered in all modes)
PV = technologies used to move various vehicles (MJ_{wheel}/MJ_{wheel})($p \times v$ matrix)
I = identity matrix, with ones on the diagonal and zeroes elsewhere
$\hat{\mathbf{i}}$ = percentage of work needed per vehicle additional to moving loads ($v \times v$ diagonal matrix)
$\hat{w}$ = work needed to move 1 tkm of load per vehicle MJ_{wheel}/tkm ($v \times v$ diagonal)

The parameter i described the inefficiency of the transport system and was defined as the ratio of actual energy consumption compared to a fully loaded vehicle without empty drives (E_{actual}/E_{ideal}).

These unit emissions and energy demands can be weighted with the fleet composition in given modes to give the emission and energy intensity of modes **EM**:

$$\mathbf{EM} = \mathbf{EV} \cdot \mathbf{VM} \tag{3.3}$$

where **EM** = emission intensity of load transported by modes, ($n \times j$ matrix, where j is the amount of modes considered)
VM = load moved by different vehicles in the fleet of a mode (tkm/tkm) ($v \times j$ matrix)

Finally, these modal emission and energy intensities can be multiplied with the modal split and overall freight performance to give the total emission intensity for transporting goods in a given year:

$$\mathbf{E} = \mathbf{EM} \cdot \mathbf{m} \cdot v \tag{3.4}$$

where **E** = emissions and energy demand of freight transport ($n \times 1$ vector)
m = the modal split ($j \times 1$ vector)
v = freight performance (tkm, scalar value)

In the FREIGHTVISION project four figures were used in the model to indicate energy and emissions: greenhouse gas emissions from fuel use ($\mathbf{E}_1$), greenhouse gas emissions from fuel manufacture ($\mathbf{E}_2$), fossil energy in fuel use and manufacture ($\mathbf{E}_3$), and total primary energy in fuel use and manufacture ($\mathbf{E}_4$). Therefore, model output was a vector **E** of four indicators $\mathbf{E} = (\mathbf{E}_1, \mathbf{E}_2, \mathbf{E}_3, \mathbf{E}_4)^T$. These figures were then combined to the environmental sustainability indicators (SI) of the FREIGHTVISION project.

(SI_1) Greenhouse gas emissions of freight transport: *"Total greenhouse gas emissions caused by long-distance freight transport by road, rail, and inland waterways within the EU-27, including all gases and both the use and manufacture of fuels."*

$$\mathrm{SI}_1 = \mathbf{E}_1 + \mathbf{E}_2$$

(SI_2) Fossil fuel share: *"Ratio of fossil primary energy and total primary energy demand for the long-distance freight transport by road, rail, and inland waterways within the EU-27."*

$$\mathrm{SI}_2 = \frac{\mathbf{E}_3}{\mathbf{E}_4}$$

Although in this study, the model was used only to produce four emission and energy figures for the aggregated EU-27, the number of emission categories is not limited by the model structure. The model could be easily applied to other pollutants and a more refined geographical resolution (emissions by country).

Due to the linear algebra used, the model could be written as a single equation, combining Eqs. (3.1), (3.2), (3.3), and (3.4):

$$\mathbf{E} = \mathbf{EF} \cdot \mathbf{FP} \cdot \hat{\mathbf{e}}^{-1} \cdot \mathbf{PV} \cdot (\mathbf{I} + \hat{\mathbf{i}})\ \hat{w} \cdot \mathbf{VM} \cdot \mathbf{m} \cdot \boldsymbol{v} \tag{3.5}$$

Equation (3.5) shows transparently the relationship between model components and all the factors that can cause change in the emissions and energy consumption of the freight transport system. Due to its relatively simple linear structure, the model is easy to analyse with linear tools, such as sensitivity analysis and Monte Carlo simulation (Saltelli et al., 2008), and structural decomposition (Ang, 2005). Tradeoffs between improving aerodynamics (w), logistics (i), and energy efficiency (e) are easily identified as their synergistic effects. The model was implemented in Microsoft Excel for ease of use and transparency.

3.2 Estimating the Emissions and Energy Consumption of the Year 2005

The model was next applied to the year 2005 freight transport system, in order to compare the results with official statistics. In the following paragraphs, we present the detailed calculations using the developed model. The purpose is both to compare the model performance to statistics and to present an example of the use of the model. The reader can follow the calculations by using the matrix operations in Microsoft Excel (MINVERSE() and MTIMES()). The first step was to obtain data for the emissions and energy demand of fuels, fuel mix, and energy efficiency of engines.

Upstream emissions of diesel production are caused by extraction of crude oil from underground reserves, transportation (shipping) to refinery, refining, and transportation to distribution. The location and the quality of the oil reserve influence the size of the emissions, as well as the transportation distances and the type of the refinery

and the co-products produced by the refinery. However, the variation is relatively low, especially if compared to total well-to-wheel (WTW) GHG emissions of diesel. Upstream emissions represent about 15% of the WTW emissions (12–14 g CO_2-eq/MJ fuel, while the direct emissions are about 73 g CO_2-eq/MJ fuel) (Ecoinvent, 2008)(JRC, 2008 vol. 2008). For biofuels, in 2005 1.05% of all transport fuels were biofuels in the EU-27 (Eurostat, 2008a). However, since most biofuels were rapeseed dimethylesters (RME) used in heavy vehicles (85% of all biofuels, (EC, 2006)), the fraction of biofuels in LDFT was higher than in the EU-27 as a whole. Approximately 3% of energy was assumed to be from biodiesel. Following common practice, the emissions of biodiesel combustion were not accounted for, but the manufacture of biodiesel caused emissions of 74 g CO_2-eq/MJ (Ecoinvent, 2008). The primary energy demand of different fuels was obtained from Ecoinvent life cycle inventory database (Ecoinvent, 2008), as were the emission intensities of different electricity-production methods. The electricity production mix was based on IEA World Energy Outlook (IEA, 2008). The energy efficiencies of engines (42% for diesel, 80% for electric) were based on the energy balance of heavy trucks (US DOE, 2006). Petrol engines were not considered to be used in long-distance, heavy-goods transport.

With the reported data on fuel emissions, fuel mix, and engine efficiencies, the emissions and energy consumption of different propulsion systems could be calculated with Eq. (3.1):

$$\mathbf{EP} = \mathbf{EF} \cdot \mathbf{FP} \cdot \hat{\mathbf{e}}^{-1} =$$

$$\begin{bmatrix} 73 & 0 & 0 \\ 12 & 74 & 123 \\ 1{,}16 & 0{,}37 & 1{,}48 \\ 1{,}17 & 2{,}23 & 2{,}85 \end{bmatrix} \cdot \begin{bmatrix} 0{,}97 & 1 & 0 & 1 \\ 0{,}03 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \cdot \begin{bmatrix} 0{,}42 & 0 & 0 & 0 \\ 0 & 0{,}42 & 0 & 0 \\ 0 & 0 & 0{,}8 & 0 \\ 0 & 0 & 0 & 0{,}42 \end{bmatrix} = \begin{bmatrix} 169 & 174 & 0 & 174 \\ 33 & 29 & 154 & 29 \\ 2{,}71 & 2{,}76 & 1{,}85 & 2{,}76 \\ 2{,}86 & 2{,}79 & 3{,}56 & 2{,}79 \end{bmatrix}$$

The first column of the results refers to a diesel truck engine, the second to a diesel train engine, third to an electric motor, and the fourth to a ship engine. For simplicity, it was assumed that ship engines run on diesel and not heavy fuel oil. The error caused by this simplification is less than 10% based on life cycle inventories on heavy fuel oil (Ecoinvent, 2008). The rows refer to direct and upstream GHG emissions, fossil energy consumption, and total energy consumption. The differences between fossil and total energy consumption are caused by biofuels for trucks and the electricity mix for electric trains.

The energy consumption of different engine types was aggregated to vehicle types using data on the energy demand, inefficiency, and propulsion mix of vehicles. The energy consumption of different vehicles was taken from the Finnish emission inventory (VTT, 2009). For 25 t and 9 t payload trucks, the energy demand (corrected with engine efficiency) was 0.25 MJ/tkm and 0.37 MJ/tkm, respectively. For diesel and electric trains, the energy consumption was 0.15 MJ/tkm and 0.12 MJ/tkm, respectively. For container ships the energy consumption was 0.13 MJ/tkm.

The **i** factor was expressed as the amount of additional work needed to move 1 tkm compared to the theoretical minimum:

$$\mathbf{i} = \mathbf{E}_{act}/\mathbf{E}_{min} - 1 \qquad (3.6)$$

The $\mathbf{E}_{min}$ is the figure reported for the work requirement at fully loaded vehicle. $\mathbf{E}_{act}$ is calculated from the distances d of loaded and empty driving required to move 1 tkm:

$$\mathbf{E}_{act} = \mathbf{E}_{load}{}^{*} d_{loaded}(\text{km/tkm}) + \mathbf{E}_{empty}{}^{*} d_{empty}(\text{km/tkm}) \tag{3.7}$$

The distances of empty and loaded driving were calculated from the empty haulage fraction and from the load factor.

The work demand for $\mathbf{E}_{load}$ is calculated based on data from VTT (2009) on work requirements for full, 70% load, and empty loads by assuming a linear correlation between energy consumption and carried load:

$$\mathbf{E}_{load} = (\mathbf{E}_{full} - \mathbf{E}_{70\%})/30\%\ {}^{*}\ \text{loading factor} + \mathbf{E}_{empty} \tag{3.8}$$

For European average long-distance travel, the loading factor was 13.1 tkm/vkm and empty haulage 25% (Pasi, 2007). This corresponded to an i-factor of 1.09 for a 25 t truck. The energy demands of trains and ships already included the inefficiencies of use, so they were not included. Using Eq. (3.2) the energy and emission intensity of different vehicles can be considered. The analysed vehicles were split into five vehicle classes: delivery trucks (<9 t payload), heavy trucks (<25 t payload), electric and diesel trains, and container ships. Eq. (3.2) then yields

$$\mathbf{EV} = \mathbf{EP} \cdot \mathbf{PV} \cdot (\mathbf{I} + \hat{\mathbf{i}}) \cdot \hat{w} =$$

$$\begin{bmatrix} 169 & 174 & 0 & 174 \\ 33 & 29 & 154 & 29 \\ 2{,}71 & 2{,}76 & 1{,}85 & 2{,}76 \\ 2{,}86 & 2{,}79 & 3{,}56 & 2{,}79 \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 2{,}09 & 0 & 0 & 0 & 0 \\ 0 & 2{,}09 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 0{,}38 & 0 & 0 & 0 & 0 \\ 0 & 0{,}25 & 0 & 0 & 0 \\ 0 & 0 & 0{,}12 & 0 & 0 \\ 0 & 0 & 0 & 0{,}15 & 0 \\ 0 & 0 & 0 & 0 & 0{,}13 \end{bmatrix}$$

$$= \begin{array}{c} \begin{array}{ccccc} \text{9 ton truck} & \text{25 ton truck} & \text{electric train} & \text{diesel train} & \text{container ship} \end{array} \\ \begin{bmatrix} 130 & 88 & 0 & 26 & 23 \\ 26 & 17 & 18 & 4 & 4 \\ 2{,}09 & 1{,}41 & 0{,}22 & 0{,}41 & 0{,}36 \\ 2{,}21 & 1{,}5 & 0{,}43 & 0{,}42 & 0{,}36 \end{bmatrix} \end{array} \begin{array}{l} \\ \text{Direct GHG} \\ \text{Upstream GHG} \\ \text{MJ fossil} \\ \text{MJ total} \end{array}$$

The next phase was to aggregate vehicle specific emission and energy intensities into modal averages. For this phase, the vehicle fleet composition in all modes was needed. For rail the volume share for electric and diesel trains (64% and 36% respectively) was obtained from the Ecoinvent database (Ecoinvent, 2008). For the road mode of transport, road count data was used. In the TREMOVE project, fleet composition was based on few road counts in Germany and in Italy (Knockaert et al., 2004). The road count data presented for highways had 16% of vehicles with a payload of less than 9 t (total mass less than 16 t). The road count data was weighted with the vehicle payload to get a rough estimate of the freight moved by different sized trucks (Table 3.1).

Table 3.1 Highway count data was weighted with the payload capacity to get the distribution of freight demand to different sized trucks

Vehicle size (*t*)	Payload (*t*)	Highway counts (%)	Counts weighted by payload (%)
3.5–7.5	3.5	12	2
7.5–16	9	4	2
16–32	20	39	40
over 32	25	45	56

Correspondently, 96% of freight volume in highways was assumed to be moved by heavy 25 t payload trucks, the remaining being on lighter (less than 9 t) payload trucks.
With that data, the modal emission and energy intensity could be calculated with Eq. (3.3):

$$\mathbf{EM} = \mathbf{EV} \cdot \mathbf{VM}$$
$$= \begin{bmatrix} 130 & 88 & 0 & 26 & 23 \\ 26 & 17 & 18 & 4 & 4 \\ 2{,}09 & 1{,}41 & 0{,}22 & 0{,}41 & 0{,}36 \\ 2{,}21 & 1{,}5 & 0{,}43 & 0{,}42 & 0{,}36 \end{bmatrix} \cdot \begin{bmatrix} 0{,}04 & 0 & 0 \\ 0{,}96 & 0 & 0 \\ 0 & 0{,}64 & 0 \\ 0 & 0{,}36 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 90 & 9 & 23 \\ 18 & 13 & 4 \\ 1{,}44 & 0{,}29 & 0{,}39 \\ 1{,}52 & 0{,}42 & 0{,}36 \end{bmatrix}$$

The result of this stage was the direct and upstream GHG emissions and fossil and total energy consumption for road, rail, and inland waterways. This result was finally aggregated to the total indicator results for long-distance freight by using published data on the modal split (75.7% road, 18.8% rail, and 5.5% inland waterways) as well as the total freight performance (Eurostat, 2008b). Since the total freight performance included short-distance freight, it was assumed that about 7.5% of freight performance would be short distance and was excluded from the results (personal communication with Olaf Meyer-Rühle, PROGTRANS). Therefore, the amount of long-distance freight transport used in the calculations was 2183 billion tkm.

The overall emissions and energy consumption for European long-distance freight were then estimated to be:

$$\mathbf{E} = \mathbf{EM} \cdot \mathbf{m} \cdot v$$
$$= \begin{bmatrix} 90 & 9 & 23 \\ 18 & 13 & 4 \\ 1,44 & 0,29 & 0,36 \\ 1,52 & 0,42 & 0,36 \end{bmatrix} \cdot \begin{bmatrix} 0,757 \\ 0,188 \\ 0,055 \end{bmatrix} \cdot \left[2183 \cdot 10^9 \right] = \begin{bmatrix} 1,55\mathrm{E}+14 \\ 3,50\mathrm{E}+13 \\ 2,54\mathrm{E}+12 \\ 2,74\mathrm{E}+12 \end{bmatrix}$$

In the result the first two rows were the amount of direct and upstream greenhouse gas emissions (in grams), amounting to 190 Mt CO_2-eq. The following two were the fossil and total energy consumption, amounting to 61 Mtoe and 65 Mtoe (million tonnes of oil equivalents, 1 toe = 41,868 MJ). The fossil fuel share was 93%.

The GHG emissions of long-distance freight transport in EU have not been estimated for that year, while several estimates on European transport total GHG emissions have been made. Therefore direct comparison was not possible between model results and official statistics. Compared to statistics the results seemed reasonable. Eurostat reported a significantly higher figure (970 Mt CO_2-eq) for the whole transport (Eurostat, 2008b), which included passenger transport, air transport, short-sea shipping, and short-distance urban freight transport. Globally, freight trucks cause about 25–30% and light duty vehicles about half of the global transport energy consumption and GHG emissions, while rail, water, and air transport cause the rest (Ribeiro et al., 2007)(OECD/ITF, 2008). In addition the energy consumption of light trucks and vans used for short distance is much higher than that of larger long-distance vehicles. On the basis of these figures, the long-distance freight share of the reported overall emissions was comparable to our estimate.

3.3 Strengths and Weaknesses of the Modelling Approach

For the historical case, using a linear algebra framework might seem too complex, since the emissions and energy consumption could have been calculated with a series of equations (one for each vehicle, engine and fuel combination). However, if the amount of assessed technologies would have increased, the amount of required equations would have increased as well. Therefore the linear algebra approach is supported, since it maintained flexibility in accounting for vehicle–technology–fuel combinations.

The use of a transparent modelling approach reduced the risks of double counting the benefits from additional technological improvements. For example, if predicted emission reductions from biofuels, engine efficiencies, logistics, and aerodynamic improvements would be 20% for all technologies compared to the current level, the combined effect of these technologies would only be 59%. If separate technology assessments would be combined without a general framework, there would be a risk of adding the benefits simply together.

The model excluded the possible influence of the transport system to the overall economy. Due to this shortfall, rebound effects were ignored. Rebound is caused when increased efficiency decreases costs, and therefore increases the use of transport. For example, improving aerodynamics and vehicle efficiencies would reduce the fuel costs of road transport and might influence the development of modal shift from road to rail. In addition the decreases in costs might increase the distances travelled, and therefore the freight performance.

Another issue which was excluded from the model was the influence of increasing biofuel-use to the other biomass industries. Depending on the future development in population, diet, and material consumption, the increase of biofuel-use might result in relocation of biomass production from the current areas to more marginal lands (such as rainforests). This phenomenon is known as indirect land use change, but including it into the model would have required a consistent world model for the scenarios analysed and was clearly outside the scope of this study.

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4 Trans-Tools

Christian O. Hansen and Jeppe Rich

Abstract Technical University of Denmark (DTU) transport used TRANS-TOOLS in the project for developing a trend congestion forecast for 2035 and a congestion scenario. This chapter briefly introduces the TRANS-TOOLS model, describes the assumption for the forecast and the scenario and includes some of the modeling results and compares them with the base year 2005.

4.1 Introduction

Technical University of Denmark (DTU) transport used TRANS-TOOLS in the project for developing a trend congestion forecast for 2035 and a congestion scenario. This chapter summarizes the assumptions and shows results from the forecast and the scenario compared with base year 2005.

The TRANS-TOOLS model is briefly introduced in Sect. 2. Section 3 includes assumptions used for the Trend 2035 Forecast and the Congestion Scenario. Section 4 includes some of the modeling results and compares them with the base year 2005.

4.2 TRANS-TOOLS Model

4.2.1 Coverage

In 2007, the first version of the TRANS-TOOLS model was delivered to the EU Commission, developed within the 6th Framework Programme. TRANS-TOOLS version 2 was finished by the end of 2008 as part of the TEN-CONNECT study, primarily including improvements to modeling of passenger transport. The following refers to this version of the model.

TRANS-TOOLS is a European-wide model which includes passenger and freight transport. The coverage area illustrated in Fig. 4.1 is divided into 1,441 zones. The model describes passenger and goods flows between and within the 1,441 zones.

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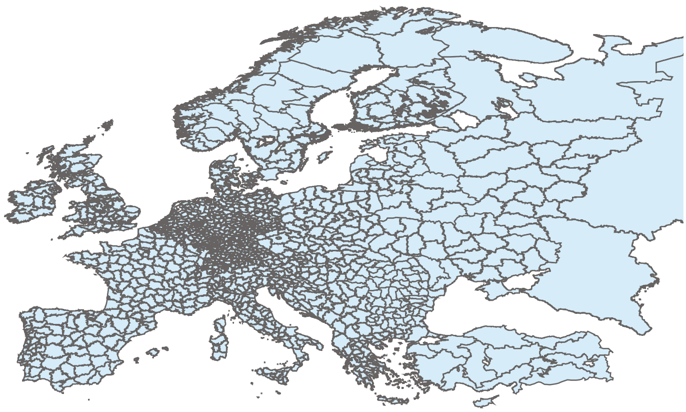

Fig. 4.1 Geographical coverage and zoning of TRANS-TOOLS

Passenger trips are segmented by mode: passenger car, train, bus, and air. Hence, slow-mode bike and walk are the only passenger modes which are not included in the model. Passenger trips by car, rail, and air are assigned onto networks to give link-load flows, e.g., number of passenger vehicles on a motorway section.

Freight flows are divided by mode: truck, rail, inland waterways, and sea. For instance, TRANS-TOOLS describes tons moved by truck between zone pairs as part of a multi-modal transport chain trans-shipped to truck or as a direct truck transport from production zone to consumption zone. Similar to passenger trips, trucks and tons are assigned onto networks except for maritime transports which are described as tons flows by ship between zone pairs.

The base year of TRANS-TOOLS is 2005. Therefore, the model describes transport flows for 2005 calibrated on the basis of statistics and counts for 2005. The 2005 travel and transport patterns are used as basis for prediction of future flows.

4.2.2 Model Structure

The passenger demand model includes sub-models of generation, destination, and mode choice to predict the future travel pattern. The generation model that produces trips by trip purpose (commute, business, private, and holiday) is mainly driven by changes to population, car ownership, and GDP. The choice of trip destination is a function of the zonal attraction and accessibility to the zone, e.g., improvements of the road network will increase the number of the trips to zones affected by the infrastructure change. Finally, the mode-choice model predicts modal split influenced by change to level-of-service (LoS), e.g., travel times and travel cost. The three sub-models are linked consistently; LoS is used to calculate mode shares which are used to aggregate the LoS files as input to distribution and generation. Consequently, changes to networks and

congestion affect generation of trips. At the same time calculation of trips per mode depends on results from the generation and distribution models.

The freight model consists of three sub-models: trade, mode choice, and logistics. The trade model calculates number of tons produced in each zone of the model and distributes them between zones. The number of tons produced depends on GDP, whereas the distribution of tons flows depends on LoS and zonal attraction. The trade model provides input to the mode-choice model, where tons between zones are split into main modes of truck, rail, inland waterways, and maritime on the basis of LoS. The logistics model calculates, provided the mode choice output, the use of distribution centers and chaining of transports to reduce the total logistics costs.

The fundamental structure of TRANS-TOOLS is shown in Fig. 4.2 below. It includes three main model components: passenger demand modeling, freight modeling, and assignment. While the assignment models load trips and tons onto the network to estimate link loads, LoS is produced. TRANS-TOOLS includes separate networks and assignment models for each mode.

Passenger cars and trucks are assigned simultaneously onto the road network considering congestion effects. The road segments of the network include information about speed limits and capacity. When vehicles are loaded onto the road segment, the driving speed is reduced and calculated on the basis of speed flow curves, which describe the relationship between speed, number of vehicles, and capacity. The speed flow relations depend on the type of road and the functions are estimated from traffic-flow surveys. The inclusion of road congestion effects creates a dependency between demand and LoS which can only be solved in an iterative procedure as illustrated in the figure below. For instance, increased congestion will reduce the number of predicted vehicle trips. When the vehicle trips are assigned to the network, congestion will be less than in the previous step, and hence, increase the mode share of passenger cars and trucks.

Whereas the assignment of trips onto the roads considers congestion, this is not the case for the other modes. Maritime transports are not assigned onto ship routs and only provided as tons flows by ship between zone pairs.

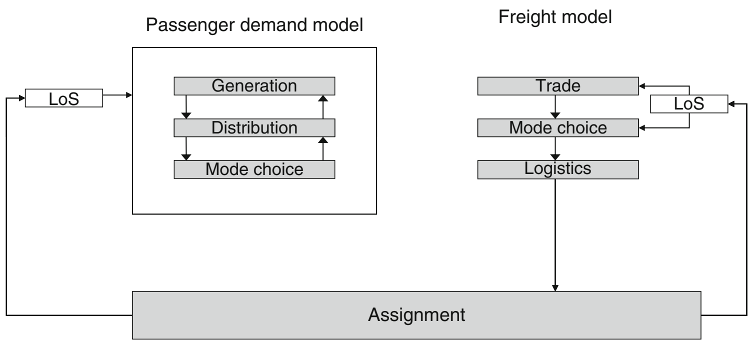

Fig. 4.2 Fundamental structure of TRANS-TOOLS

4.2.3 TRANS-TOOLS as Forecasting Tool

The purpose of TRANS-TOOLS is to predict future transport behavior. The user inputs assumptions, e.g., economy development, infrastructure, and transport costs describing the future year scenario. The model is run to produce outputs of future transport indicators, e.g., tkm. The process is Fig. 4.3.

The assumptions used as input to TRANS-TOOLS include zonal information, network and network attributes, costs, and logistics. The zonal input required to run the model is population, employment, car ownership, GDP, and hotel capacity. The information has to be provided for each of the 1,441 zones of the model. Whereas population, car ownership, and GPD influence trip generation, employment and hotel capacity are trip attraction variables which influence choice of destination.

Networks describe the infrastructure used to carry passengers and goods. For instance, the user may add new segments or upgrade existing segments. The road network includes information about length of road segment, speed limit, capacity per lane, and number of lanes. The rail network primarily includes information about length of rail segment, average speed (included stop at stations), and departures per day. The air network contains information about flying time, fare, departures per day, and transfer times. The inland waterways network has information about segment length, and average speed by type of vessel.

The costs of using passenger cars include driving costs and road user charges. While driving costs are travel distance calculated by the assignment model multiplied by user specified average costs per km, road user charges are coded as attributes in the network. The cost for using rail and bus services are provided by a fare matrix which can be edited by the user. The air fare is coded to links in the air network.

The truck transport costs are based on travel distance and time calculated by the assignment model multiplied with user specified per km and per hour costs supplemented by truck road user charges specified in the network database. Similarly, the user must specify per km and hour costs for rail and inland waterways to multiply transport distance and time from the assignment models to produce transport costs for rail

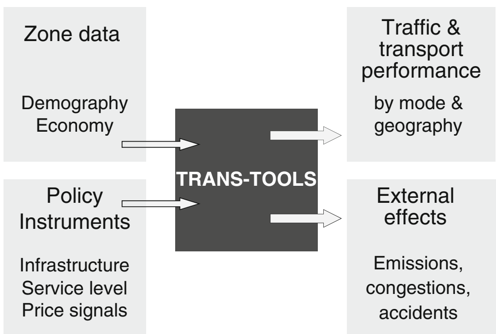

Fig. 4.3 Model application

and inland waterways. Maritime transport costs and times are provided in matrix form, which the user may edit.

The load factor is the main logistics variable the user may want to change. Load factors are used per mode and commodity group. Additionally, the logistics model includes input variables to be changed by more experienced users, e.g., terminal costs.

4.3 Forecast Assumptions

4.3.1 Trend Forecast 2035

In the project, a trend forecast 2035 was developed, describing a business-as-usual projection. The assumptions are outlined below:

- Infrastructure
- Zonal data
- Transport costs

Road and rail infrastructure 2035 is based on "Sustainable Europe 2030" developed in the TEN-CONNECT study. Figures 4.4 and 4.5 show road and rail infrastructure developments already on-going or designed to be available in 2020 used in the baselines

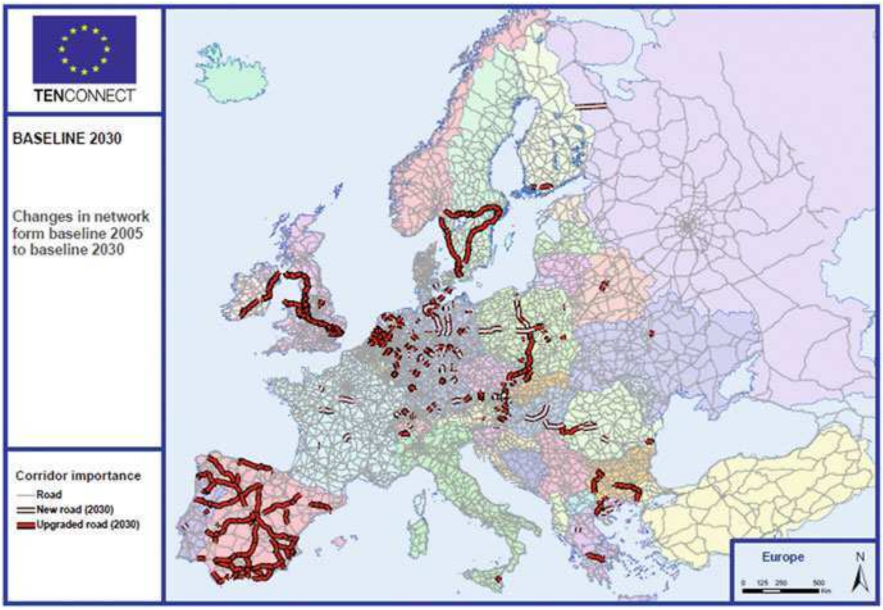

Fig. 4.4 Designed road infrastructure available in 2020
Source: TEN-CONNECT

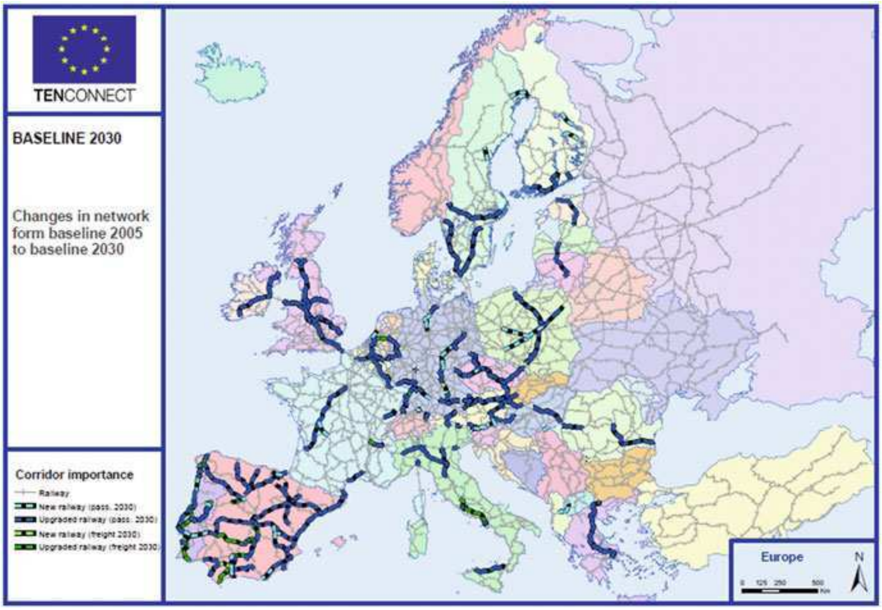

Fig. 4.5 Designed rail infrastructure build in 2020
Source: TEN-CONNECT

scenarios 2020 and 2030 of the TEN-CONNECT study and FREIGHTVISION. In the congestion forecast, road and rail infrastructure is further developed to include available plans. Figures 4.6 and 4.7 illustrate the upgrading based on existing plans compared with already on-going and designed infrastructure.

The air network is compared with 2005 improved with low-budget airlines between East European capitals and West European capitals to substitute non-low-budget lines in the 2005 network, and seven new low-budget lines have been assumed between East Europe capitals and Brussels.

The inland waterways network is identically to 2005.

The following zonal input data are required to run the model:

- Population
- Employment
- Car ownership
- GDP
- Hotel capacity (no. of bed places)

The population forecast is based on the EUROSTAT forecast 2008 for countries within EU 27, Switzerland and Norway. The population forecast is except for UK, France, Switzerland, and Norway detailed at NUTS 2 level. The UN 2006 forecast is used for other countries within the coverage of TRANS-TOOLS. Table 4.1 shows the population forecast aggregated per country. In the total coverage area of TRANS-TOOLS,

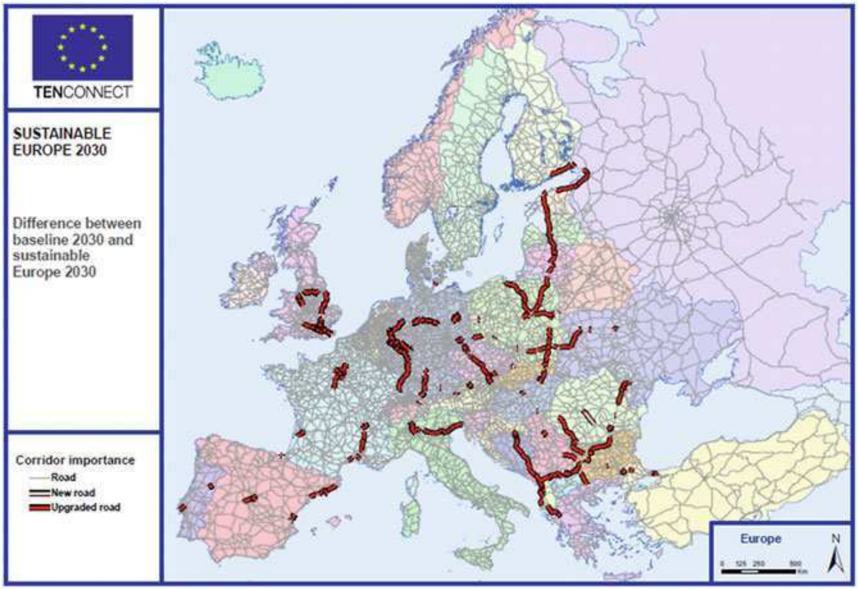

Fig. 4.6 Road infrastructure development in the Sustainable Europe compared with on-going and designed infrastructure development
Source: TEN-CONNECT

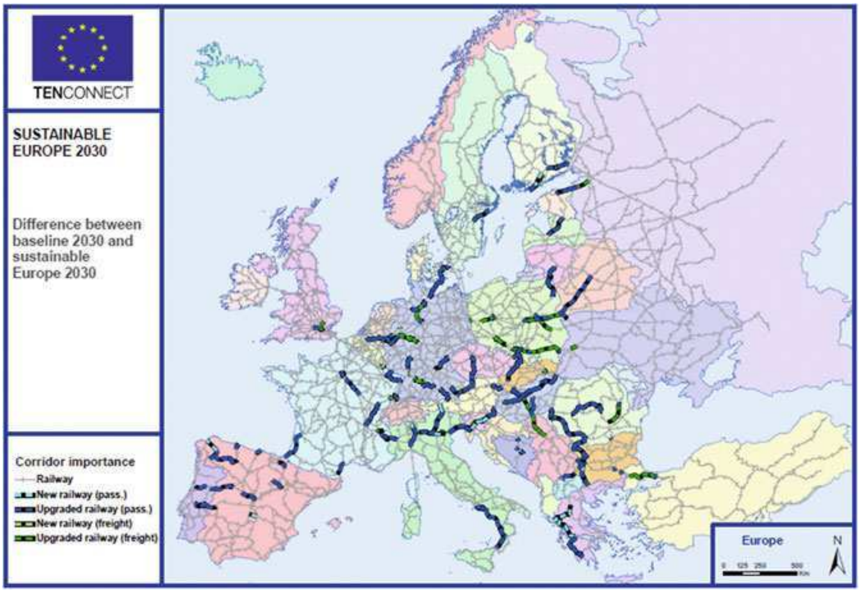

Fig. 4.7 Rail infrastructure development in the Sustainable Europe compared with on-going and designed rail infrastructure development
Source. TEN-CONNECT

Table 4.1 Population forecast

Country	Population		Relative change 2005–2035
	2005	2035	
Austria	8,236,100	9,068,028	10.1%
Belgium	10,478,100	11,854,011	13.1%
Bulgaria	7,739,600	6,578,660	−15.0%
Cyprus	757,800	1,128,806	49.0%
Czech Republic	10,235,800	10,339,192	1.0%
Denmark	5,419,300	5,857,225	8.1%
Estonia	1,346,200	1,251,966	−7.0%
Finland	5,246,300	5,564,257	6.1%
France	62,444,000	70,643,718	13.1%
Germany	82,468,300	79,169,568	−4.0%
Greece	11,104,000	11,664,807	5.1%
Hungary	10,087,100	9,481,874	−6.0%
Ireland	4,159,200	6,085,566	46.3%
Italy	58,607,300	62,159,258	6.1%
Latvia	2,300,600	1,981,704	−13.9%
Lithuania	3,414,100	3,008,463	−11.9%
Luxembourg	457,300	622,305	36.1%
Malta	403,500	427,955	6.1%
Netherlands	16,319,800	17,135,790	5.0%
Poland	38,165,100	36,256,845	−5.0%
Portugal	10,549,400	11,401,879	8.1%
Romania	21,634,300	19,492,291	−9.9%
Slovak Republic	5,386,900	5,225,293	−3.0%
Slovenia	2,000,400	2,000,400	0.0%
Spain	43,398,600	52,794,169	21.6%
Sweden	9,029,500	10,306,398	14.1%
United Kingdom	59,880,200	66,533,557	11.1%
Albania	3,135,000	2,664,750	−15.0%
Belarus	9,800,300	8,330,255	−15.0%
Bosnia	3,842,600	3,266,210	−15.0%
Croatia	4,443,500	3,954,715	−11.0%
Iceland	296,700	434,119	46.3%
Liechtenstein	34,800	47,357	36.1%
Macedonia	2,035,200	1,811,328	−11.0%
Moldavia	3,600,400	3,204,356	−11.0%
Montenegro	623,000	554,470	−11.0%
Norway	4,623,200	5,661,062	22.4%
Russia	143,474,200	139,169,974	−3.0%
Serbia	9,497,200	8,452,508	−11.0%
Switzerland	7,437,300	8,727,445	17.3%
Turkey	72,064,800	69,902,856	−3.0%
Ukraine	47,100,600	45,687,582	−3.0%
Total	803,277,600	819,902,972	2.1%
EU 27	491,268,800	518,033,985	5.4%

Source: EUROSTAT 2008 and UN 2006

the population is assumed to grow about 2% from 2005 to 2035. The expectation within EU 27 is slightly higher–about 5%.

Technically speaking, the demographical development will only have indirect impact on the freight demand modeling. The population does not enter the trade model and “size” effects are solely described by GDP effects. Even so, the population level may affect the freight indirectly through accessibility changes. Increasing congestion due to an increasing population may increase travel costs for freight as well and cause substitution effects to other modes.

Employment is assumed to follow the development in population, keeping the ratio of jobs to population unchanged at zonal level compared with 2005. In the model, employment works as an attraction variable in the passenger model re-distributing the transport patterns. In TRANS-TOOLS, it has no direct influence on freight transport behavior. Table 4.2 includes car ownership assumptions for 2035. It has been developed at country level and assumed to be identically for all zones within the country. In total, the car ownership is expected to be doubled from 2005 to 2035. Within EU 27 the car ownership is expected to increase about 50% from 2005 to 2035. Increased car ownership induces more road traffic and congestion, which influence travel times for both passenger cars and trucks.

Summary of the GDP growth measured as annual growth rates (fixed prices) is shown in Table 4.3. GDP 2035 has been derived under the assumption that the relative changes to GDP are equal for all zones within the country. In total, GDP in fixed prices is assumed to increase about 60% (1.7% per year) from 2005 to 2035 covering a range from 28% in Italy to 160% in Slovak Republic, Turkey, Russia, and Ukraine.

In the freight model, GDP assumptions are also provided for regions outside Europe which will influence overseas trade volumes and flow pattern. Generally, the GDP growth is assumed to be higher outside Europe, in particular, in Asia and Africa with increase of about 240% compared with 2005.

In the model, GDP will influence the trip frequency, mode choice, and trade volume. GDP growth will increase personal income, and evidence show that high-income groups travel more often and longer than low-income groups. Higher income groups also have higher value-of-time (VOT) which changes preferences from use of slow modes like bus and regional trains to car use. GDP is the primarily driver of freight trade.

The assumed GDP growth is consistent with EUROSTAT and forecast developed by ProgTrans, prior to implications from financial crises. Generally, the GDP growth has been low in 2008 and negative in 2009. Hence, the more recent pessimistic expectation to future GDP growth has not been incorporated into the Trend 2035 Forecast. Therefore, compared with the current estimates of expected GDP growth, the Trend 2035 Forecast will overestimate trade flows.

Hotel capacity is an attraction variable for vacation trips. It has been assumed unchanged compared with 2005 and has no impact on freight modeling.

The transport-cost assumptions for 2035 equals the assumptions used in baseline 2030 of TEN-CONNECT. In fixed prices, it is assumed that

Table 4.2 Car-ownership assumptions

Country	Passenger cars per 1,000 inhabitants		Relative change 2005–2035
	2005	2035	
Austria	499	738	48%
Belgium	481	595	24%
Bulgaria	330	762	131%
Cyprus	472	739	57%
Czech Republic	385	774	101%
Denmark	369	597	62%
Estonia	319	770	141%
Finland	436	754	73%
France	453	679	50%
Germany	537	690	28%
Greece	380	752	98%
Hungary	289	735	154%
Ireland	368	693	88%
Italy	568	683	20%
Latvia	245	768	213%
Lithuania	387	792	105%
Luxembourg	656	703	7%
Malta	636	793	25%
Netherlands	401	566	41%
Poland	337	766	127%
Portugal	298	561	88%
Romania	168	713	324%
Slovak Republic	236	765	224%
Slovenia	479	777	62%
Spain	438	673	54%
Sweden	436	719	65%
United Kingdom	448	647	44%
Albania	58	374	545%
Belarus	181	668	269%
Bosnia	117	566	384%
Croatia	312	770	147%
Iceland	563	789	40%
Liechtenstein	688	789	15%
Macedonia	124	556	348%
Moldavia	81	440	443%
Montenegro	191	660	246%
Norway	413	696	69%
Russia	177	734	315%
Serbia	156	614	294%
Switzerland	485	629	30%
Turkey	80	589	636%
Ukraine	118	668	466%
Total	329	681	107%
EU 27	439	686	56%

Table 4.3 GDP projection assumed in 2035

Country	GDP (mio. Euro)		Relative change 2005–2035
	2005	2035	
Austria	245,330	394,075	61%
Belgium	301,966	449,719	49%
Bulgaria	21,883	42,030	92%
Cyprus	13,659	31,772	133%
Czech Republic	100,320	202,912	102%
Denmark	207,756	310,533	49%
Estonia	11,209	24,922	122%
Finland	157,162	269,410	71%
France	1,688,712	2,620,975	55%
Germany	2,244,522	3,189,358	42%
Greece	198,609	373,447	88%
Hungary	88,914	168,459	89%
Ireland	161,498	361,098	124%
Italy	1,423,048	1,819,101	28%
Latvia	13,012	30,358	133%
Lithuania	20,673	48,396	134%
Luxembourg	30,032	60,064	100%
Malta	4,756	9,102	91%
Netherlands	508,964	801,329	57%
Poland	244,420	486,040	99%
Portugal	149,010	228,879	54%
Romania	79,587	185,682	133%
Slovak Republic	38,480	100,137	160%
Slovenia	28,252	54,894	94%
Spain	908,450	1,504,289	66%
Sweden	294,674	513,292	74%
United Kingdom	1,812,927	3,008,620	66%
Albania	6,582	12,644	92%
Belarus	24,265	46,619	92%
Bosnia	8,655	16,626	92%
Croatia	31,260	60,076	92%
Iceland	13,084	29,254	124%
Liechtenstein	2,941	5,882	100%
Macedonia	4,676	8,987	92%
Moldavia	2,399	4,610	92%
Montenegro	1,815	3,488	92%
Norway	242,935	431,589	78%
Russia	614,410	1,598,935	160%
Serbia	23,093	44,387	92%
Switzerland	299,472	423,708	41%
Turkey	290,503	756,003	160%
Ukraine	69,085	179,776	160%
Total	12,632,999	20,911,477	66%
EU 27	10,997,825	17,288,893	57%

- Operating costs for passenger cars increases by 7% relative to 2005.
- Rail and bus fares increases with 50% of the GDP growth up to a 30% increase compared with 2005-fares.
- Air fare is assumed unchanged compared with 2005.
- Truck-operating costs increase 4% relative to 2005 (exclusive charging).
- Freight-transport costs by rail decrease 10% relative to 2005.
- Maritime-transport cost increase 4% relative to 2005.
- Transportation costs by inland waterways are unchanged compared to 2005.

It is expected that the world oil price will follow the development indicated by the US Energy Information Administration in their latest forecast (spring 2008). The price per barrel of oil is expressed in 2006 US$ per barrel. Compared to 2005, the low-sulfur light crude oil price is expected to increase by 2% in 2020 and 20% in 2030 above the 2005 level. This development seems to contradict the actual development during the first half of 2008, where the price of oil has now passed 115 US$ per barrel (April 2008). However, in December 2008 the price per barrel had dropped to 43 US$ in current 2008 prices. Therefore, the assumption of an increase of 20% of the oil price in 2030 measured in fixed prices is maintained. However, it illustrates how difficult long-term forecasting is in the middle of the current crisis.

Based on the technological development (more efficient engines, more emission free vehicles), it is expected that fuel consumption in road transport will decrease with 0.5% p.a. This implies an increase in fuel costs per km in 2030 of about 7%. It is assumed that vehicles running on non-fissile fuels will constitute only a small proportion of the vehicle fleets, mostly in the major urban areas in EU 15.

Technological development in terms of improved efficiency, both in terms of better utilization of the trucks and more efficient load planning, will partly offset the 7% fuel cost increase. As a result, it is assumed that distance costs for trucks will increase with 4% up to 2030 measured in fixed prices.

Toll charges come on top of the general operational costs. The charging is based on the Vignette directive impact analyses; approximately 0.5 Eurocent for passenger cars is valid for the whole network within EU 27. For road freight, internationalization of external costs is applied, and motorway charges are applied as a distance cost in most countries resulting in approximately 7 Eurocent on rural roads, and 15 Eurocent on motorways and urban areas. In the Vignette countries charges for using the motorway system is paid in terms of a Vignette. On top of the Vignette, comes the German MAUT, which is only active in Germany.

For rail freight, it is assumed that country-dependent rail transport cost is influenced by cost of man power, traction costs, infrastructure fees, and cost of equipment. The expected growth of these costs is counteracted by improved use of ICT, more efficient planning of the transports, and efficiency gains attributable to improved interoperability. In this way the costs of rail freight transport is expected to decrease by 10%.

4.3.2 Congestion Scenario

The Trend Forecast 2035 described above is the basis for the congestion scenario. In an attempt to achieve the goals of reduced congestion of 33% from 2005 to 2035, a combination of measurements has been introduced related to:

- Road user charges
- Improved logistics
- Improved road infrastructure utilization

The three measures have been chosen because they target the reduction of congestion rather efficiently. With respect to emission, fuel, and accident reductions, other measures are likely to be more relevant and optimal.

Passenger cars and vans account according to TRANS-TOOLS for 95% of all delayed vehicle hours in 2005 within EU 27. Hence, road congestion is primarily influenced by passenger cars. In the trend forecast up to 2035, increases in GDP and car ownership are assumed. Therefore, it is necessary to apply measures which will reduce the future use of passenger cars and increase the utility of passenger cars to reduce road congestion. A road user charge will do the job to reduce the use of car and increase the occupancy rate. It is a more efficient measure to reduce congestion than increase fuel prices, because the impact may be off-set by more fuel-efficient engines or use of electric engines. In the forecast, we have assumed a flat toll cost of 0.15 Euro per km (2005-prices) for passenger cars on all roads, which is a significant increase in the marginal cost for using passenger cars. Depending on the actual fuel costs, it compares with an increase of 2–3 times the cost to use a car. We have for the sake of simplicity assumed same km-charge on all roads. Obviously, a more optimal strategy to reduce congestion would be to differentiate the charge depending on the level of congestion.

The truck user charge has been assumed to be the double of passenger cars for all roads, i.e., a flat charge of 0.30 Euro per km. In Trend 2035 Forecast, we assumed costs of about 7 Eurocents per km in rural areas and 15 Eurocents per km on motorways and in urban areas. The assumption of 30 Eurocents per km is, except for Germany, 2–3 times larger than indicated in the trend forecast.

In the model, we have translated improved logistics efficiency into an increase in truck load factor of 20% compared with 2005. It is not analyzed how the improved efficiency eventually will be achieved, but it is expected that high truck-driving costs, will lead to more optimal use of trucks with less empty vehicles. The 20% level is not based on evidence, but used to indicate a significant and realistic improvement in truck utilization.

Finally, it is assumed that road capacity overall is increased by 20% compared with 2005. A larger capacity can be achieved by, e.g., ITS, improved vehicle technology, and investments in road network. Studies show that break-down of traffic flow occurs at large volumes today than, e.g., 20 years ago. For instance, the lane capacity of a motorway is about 2,300 passenger car units according to the Highway

Capacity Manual (HCM 4), where it was assumed to be about 2,000 passenger car units 30 years ago. Historically, the increase in road capacity is contributed by many factors, e.g., improved vehicle technology (e.g., improved break technology), improved driver skills, improved roads, and speed regulations. Hence, an increase in road capacity of 20% could realistically be achieved over period of 30 years with moderate initiatives.

4.4 Results

4.4.1 Passenger Transport

Table 4.4 shows the number of passenger trips by mode for 2005, trend 2035 and scenario 2035. In total, the number of trips is expected to increase by 49% from 2005 to 2035 in the trend forecast and by 43% in the scenario. The increase in number of trips is contributed primarily by increases in car ownership and income.

However, mode shifts are the major difference between the trend forecast and the scenario. While the number of car passengers increases from the trend to the scenario, number of car drivers decrease. Hence, the car occupancy increases as expected from trend to scenario due to the higher travel costs. The car occupancy predicted by the model is also higher in scenario 2035 than in 2005 off-setting the increases in car ownership.

Bus experiences a decrease in ridership due to fare increases from 2005 to trend 2035. Train passengers experience the same fare increases; however, for long distance trips it is in many regions compensated by improved services. Because travel distances are predicted to increase, the transport performance in passenger km for train will, however, increase more than number of trips from 2005 to trend 2035.

Figure 4.8 shows the mode shares calculated on the basis of trips by mode within the coverage area of TRANS-TOOLS.

Table 4.4 Forecasted mio. passenger trips within TRANS-TOOLS coverage area

Mode	Mio. Trips			Relative change	
	2005	Trend 2035	Scenario 2035	2005 to Trend 2035 (%)	2005 to Scenario 2035 (%)
Car driver	240, 385	373, 849	308, 148	56	28
Car passenger	137, 560	213, 838	247, 902	56	80
Bus	37, 110	35, 642	39, 500	−4	6
Train	6, 362	6, 484	7, 230	2	14
Airplane	0, 483	0, 557	0, 633	15	31
Total	421, 900	630, 370	603, 414	49	43

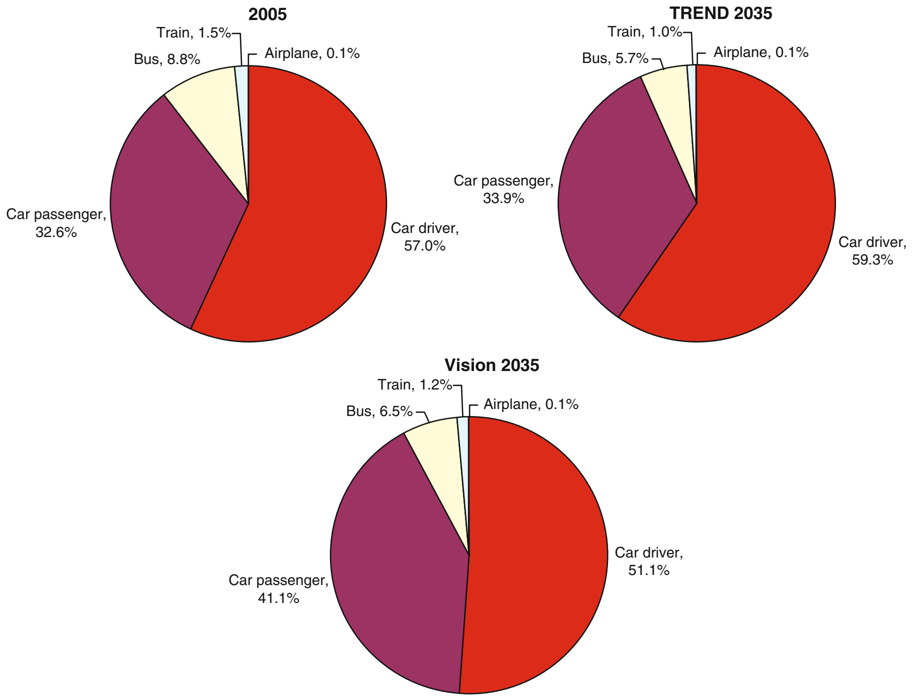

Fig. 4.8 Trips mode shares within the coverage area of TRANS-TOOLS

4.4.2 Freight Transport Performance

Table 4.5 shows the freight transport performance (tkm) within EU 27 estimated by the TRANS-TOOLS for 2005, trend 2035, and scenario 2035. In trend 2035, the transport performance is predicted to increase by 32% with slightly highest increase for rail freight transport. In the scenario the transport performance is estimated to increase only by 15% compared with 2005. The lower increase in tkm in the scenario compared with the trend forecast is mainly due to reduced transport distances, i.e., commodities are produced and sold closer to the marked. The change in transport behavior and logistics is caused by higher road transport costs in the scenario compared with the trend.

The higher road charges in scenario 2035 compared with trend 2035 is reflected in mode changes. Whereas tkm by road only increases few percents from 2005 to Scenario 2035, tkm by rail and inland waterways is predicted to increase about 50%. Since the model does not consider capacity restrictions in the rail and inland waterway systems, it may not be realistic without investments.

Table 4.6 shows tkm by truck in EU 27 segmented by country in trend 2035 and scenario 2035 compared with base year 2005 estimated by the model. Truck freight transport is not considered within Malta and Cyprus, because ETIS 2000 and ETIS 2005 databases used in TRANS-TOOLS do not include domestic transport for the

Table 4.5 Forecasted 1,000 mio, tkm within EU 2, excl. Malta and cyprus

Mode	1,000 mio. Tkm			Relative change	
	2005	Trend 2035	Scenario 2035	2005 to trend 2035 (%)	2005 to scenario 2035 (%)
Truck	1, 794	2, 312	1, 875	29	5
Rail	445	644	672	44	51
IWW	130	176	184	35	42
Total	2, 369	3, 132	2, 731	32	15

Table 4.6 Truck tkm (1,000 mio. tkm) within EU 27, excl. Malta and Cyprus

Country	Truck tkm (1,000 mio.)			Relative changes	
	2005	Trend 2035	Scenario 2035	2005 to trend 2035 (%)	2005 to scenario 2035 (%)
Austria	32.3	41.8	33.6	29	4
Belgium	50.2	57.5	46.3	15	−8
Czech Republic	23.5	34.4	25.9	46	10
Denmark	22.1	25.3	20.4	14	−8
Estonia	2.2	3.3	2.6	49	18
Finland	31.3	43.5	35.3	39	13
France	289.5	374.7	298.3	29	3
Germany	407.6	464.1	382.5	14	−6
Greece	27.9	59.7	51.1	114	83
Hungary	14.8	18.4	14.2	24	−4
Ireland	17.0	32.6	26.7	92	57
Italy	203.1	226.9	184.4	12	−9
Latvia	5.2	6.3	4.8	21	−9
Lithuania	10.6	13.0	10.4	23	−2
Luxembourg	3.4	4.5	3.4	29	−1
Netherlands	54.0	62.3	50.4	15	−7
Poland	73.0	120.7	97.2	65	33
Portugal	22.6	30.6	24.7	36	10
Slovak Republic	8.3	18.3	12.8	120	53
Slovenia	9.4	8.5	6.1	−10	−35
Spain	231.6	335.5	272.2	45	18
Sweden	36.4	51.2	41.4	41	14
United Kingdom	165.1	224.3	184.0	36	11
Bulgaria	28.7	21.5	15.7	−25	−45
Romania	24.4	32.9	30.4	35	25

two countries. In particular, East European countries like Bulgaria, Romania, and Slovenia domestic transports are described quite roughly by the databases used in TRANS-TOOLS, making forecast predictions uncertain.

In all countries of EU, the scenario 2035 reduces tkm by truck compared with trend 2035. In some countries (Belgium, Denmark, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, and Bulgaria), the forecast even indicates a negative development from 2005 to scenario 2035 in truck transport performance.

Table 4.7 shows rail tkm within EU 27 segmented by country in trend 2035 and scenario 2035 compared with model results for base year 2005. For instance, Slovak Republic, Hungary, and Romania are estimated to have increases of more than 100% from 2005 to trend 2035. A closer look at results reveals that trade flows for some bulk commodity groups like metal products, building materials, and chemicals are estimated to grow at a large rate in those countries. Since the rail transport share must be

Table 4.7 Rail tkm (1,000 mio. tkm) with EU 27

Country	Rail tkm (1,000 mio.)			Relative changes	
	2005	Trend 2035	Scenario 2035	2005 to Trend 2035 (%)	2005 to Scenario 2035 (%)
Austria	16.6	24.2	25.9	46	56
Belgium	9.1	10.2	10.9	12	20
Czech Republic	13.3	24.3	25.9	82	95
Denmark	2.5	3.7	3.9	50	56
Estonia	11.6	19.7	20.2	70	74
Finland	12.3	18.1	19.3	47	56
France	38.5	51.4	53.5	33	39
Germany	107.1	120.5	123.5	13	15
Greece	0.7	1.1	1.2	64	67
Hungary	9.1	19.4	22.1	113	142
Ireland	0.3	0.5	0.5	61	62
Italy	25.9	30.0	31.2	16	21
Latvia	21.2	31.3	31.0	48	46
Lithuania	16.5	23.1	23.8	40	44
Luxembourg	0.5	0.6	0.7	18	37
Netherlands	6.1	6.7	7.2	9	17
Poland	51.4	94.1	99.4	83	93
Portugal	3.0	4.2	4.3	39	42
Slovak Republic	7.9	18.3	19.9	133	153
Slovenia	4.6	8.3	8.8	79	89
Spain	13.6	20.6	21.2	52	56
Sweden	21.8	30.0	30.8	37	41
United Kingdom	27.1	35.8	36.3	32	34
Bulgaria	7.0	11.7	11.9	67	70
Romania	17.6	36.3	38.6	106	119

Table 4.8 Inland waterways tkm (1,000 mio. tkm) within EU 27

Country	IWW tkm (1,000 mio.)			Relative changes	
	2005	Trend 2035	Scenario 2035	2005 to Trend 2035 (%)	2005 to Scenario 2035 (%)
Austria	3.0	6.1	6.5	108	121
Belgium	9.2	9.8	10.2	7	11
Czech Republic	0.0	0.0	0.0	61	79
Finland	0.0	0.0	0.0	0	0
France	9.3	11.5	12.0	24	29
Germany	57.3	76.5	79.6	34	39
Hungary	4.1	9.1	10.0	122	145
Italy	0.0	0.0	0.0	0	0
Lithuania	0.0	0.0	0.0	39	39
Luxembourg	0.0	0.0	0.0	0	0
Netherlands	36.2	42.2	43.8	16	21
Poland	0.3	0.6	0.6	72	79
Slovak Republic	0.3	0.6	0.6	121	135
United Kingdom	0.2	0.3	0.3	33	33
Bulgaria	0.9	1.7	1.9	94	114
Romania	8.9	17.2	18.8	94	112

expected to be over average for bulk products, it will together with more international trade contribute to a large increase in tkm by rail.

Table 4.8 shows tkm by inland waterways estimated for Trend 2035 and Scenario 2035 compared with 2005 model results. Most important to notice are the growths in Belgium, France, Germany, and Netherlands contributed primarily by a general growth in freight transport volumes. However, transport by inland waterways is treated simplistically in TRANS-TOOLS and results should not be over interpreted.

4.4.3 Calculation of Congestion

Theoretically, delay is the difference between travel time in free flow conditions and travel time influenced by the actual traffic on the road segment. In practice, it is for instance the difference between travel time driving in low-traffic conditions (e.g. at night) and travel time in the rush hour.

In TRANS-TOOLS, travel time on a road segment is predicted by speed-flow curves as a function of number of vehicles (passenger car units), road capacity, and free flow speed. Hence, few vehicles on the road segment will reduce the speed compared with free flow speed. It would not be correct to interpret a model estimated difference of a few km/h as real delay, since travel time in practice most likely will be unaffected by few vehicles on the road. Second, congestion has different severity and duration, and minor speed reductions caused by other vehicles will often not be perceived as congestion by

the driver. In a Danish study on congestion, a reduction of travel speed by 20% was considered as insignificant congestion (level-of-service A or B in Highway Capacity Manual 2000). If we use the same approach, we define an acceptable free speed as:

$$v_{\mathrm{acc},i} = \begin{bmatrix} 0.8\ v_{\mathrm{ff,i}} & \text{passenger cars and vans} \\ \min(80,\ 0.8\ \mathrm{v}_{\mathrm{ff},i}) & \text{trucks} \end{bmatrix} \tag{4.1}$$

Since trucks are generally not allowed to drive faster than 80 km/h on rural roads, the acceptable speed is separated between passenger cars, vans, and trucks. For instance, if M_i is number of passenger cars on road link i of length l_i in time interval t, the delay is estimated from:

$$\Delta t_{t,i} = \frac{M_{t,i} l_i}{(v_{\mathrm{acc},i} - v_{t,i})} \tag{4.2}$$

The total delay is then found by aggregation over the entire network and time periods of the model. In 2005, TRANS-TOOLS estimates based on the formulas above that over 12 mio. hours are wasted in road congestion on an average annual day within EU 27. It is likely an underestimation, because many urban roads are not included in TRANS-TOOLS. Obviously, the large countries UK, Germany, Italy, France, and Spain contributes much to the total delay, but Netherlands also have a fairly high share of congestion.

In Trend 2035, the delay is predicted to increase by 120%. However, Scenario 2035 shows that the trend may be reversed with a combination of more or less dramatic

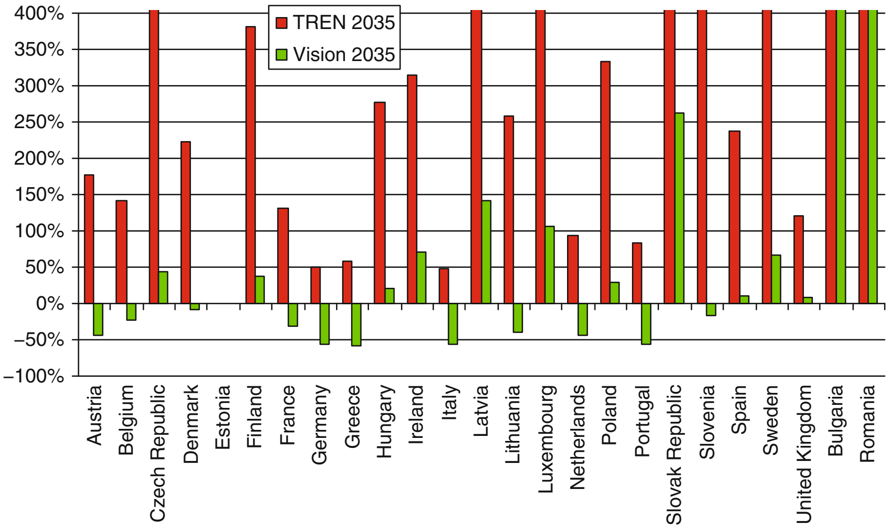

Fig. 4.9 Growth in congestion measured as delayed hours in Trend 2035 and Scenario 2035 compared with 2005

instruments. In Scenario 2035, the number of delayed hours is reduced by 18% compared with 2005. The reduction separately for trucks and passenger cars is 26% and 18%, respectively. The reduction for trucks is larger, because the increase in traffic performance is lower for trucks than for passenger cars.

Whereas congestion continues to grow in Scenario 2035 for former East European countries, e.g. Bulgaria, Romania, Slovak Republic, and Czech Republic, reductions are significant in other countries like Germany, Austria, Netherlands, Italy, Portugal, and Greece. Fig. 4.9 illustrates growth in congestion in EU 27 countries (excl. Malta and Cyprus) in Trend 2035 and Scenario 2035 compared with 2005. Congestion in Malta and Cyprus cannot be assessed by TRANS-TOOLS, because trips are not assigned onto network. Increases of more than 400% compared with 2005 are cut-off in the figure.

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Part III
Analysis

5 External Factors

Olaf Meyer-Rühle

Abstract Chapter 5 familiarizes the reader with the context in which the long-distance freight transport sector is developing, identifying the drivers in three main areas: (1) transport policy trends, (2) technology trends, and (3) demand-related mega trends. Socio-economic variables, in particular population, gross domestic product, and international trade are of course the main drivers of transport demand; they are the basis for the forecast of transport performance, energy requirements, and emissions in the subsequent chapter. Policy as well as technology trends help to understand the mechanisms to counteract the demand trends in order to meet sustainability criteria and mitigate external costs, primarily emissions.

5.1 Introduction

To get insight into past and future development of freight transport, the key influencing factors, which trigger and shape freight transport's future development, must be understood. These key impact factors are referred to as key drivers. Freight transport has many drivers. The key drivers have been developed in the FREIGHTVISION process in

- Work Package 2: Policy perspective (EU policies, national policies, and key demonstration projects),
- Work Package 3: Technology perspective (infrastructure technologies and intelligent transportation, vehicle and engine technologies, logistics technologies),

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- Work Package 4: Demand-related mega trends (demographic and economic trends, logistics trends, congestion trends, emission trends, energy developments).

It must be stressed that individual key drivers are not independent from the others. On the contrary, there are many interdependencies and linkages in a very complex causes-and-effects system. Therefore, the presentation in this chapter of key drivers and main trends is a simplification, necessary to elaborate the really important aspects.

The starting point for analyzing the key drivers is to describe their definition as well as their development trend. The *Trend* is the observed development of the past, projected into the future, whereby it is assumed that there will be no drastic impacts neither from the inside of the transport system nor from the outside. This kind of development is very often also called *Business-as-usual* (BAU) development, as it is assumed that all relevant actors like politicians, enterprises, and consumers will continue acting as usual. Therefore in a trend analysis, the political and private actions already taken are considered, and future efforts are assumed to be taken with a comparable effort like in the past. So neither a radical behavioral change nor a radical technology or market development will occur in a trend development. The trends thus identified and described will be used in the further process of the FREIGHTVISION project to establish BAU forecasts as reference cases against which the visions are developed at a later point.

5.2 Policy Trends

5.2.1 European Policy Trends

Ronald Jorna, Hans Zuiver, David Bonilla and Nihan Akyelken

One of the fundamental principles of the European Union is the unrestricted movement of persons and goods within the Union's boundaries. The free movement is made possible by an EU-wide regulatory and policy framework.

As geographical, economic, and political structures differ from country to country, a common transport policy is difficult to enact. A regulatory framework governed by a common denominator for the whole EU may be quite inefficient. An important function of the EU transport policies is to provide, in addition to the legal framework, a common guidance for national policies in order to maintain coherence among the Member States within the whole EU.

The EU has recently confirmed its 20-20-20 strategy: to reduce its overall emissions to at least 20% below 1990 levels by 2020, to increase energy efficiency by 20% and to increase the share of renewables in energy use to 20% by 2020. Emissions from sectors not included in the EU Emissions Trading Scheme, including transport, will be cut by 10% from 2005 levels by 2020. This has mostly shaped the EU policies relevant for LDFT. TEN-T infrastructure program and Marco Polo II are the key elements.

It must be noted that most of the EU policies have a limited time horizon. Climate change policy targets go up to 2020, but the rest of the policy targets are usually set for 2010–2015.

5.2.1.1 Key Drivers

Increasing openness of the Member States, the EU enlargement, and the ambitious Lisbon Strategy to become "the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with respect for the environment by 2010" can be recognized as the three main drivers of most of the EU policies. Following this, environmental sustainability and efficiency have become priorities in the transport sector.

Reducing dependency on road for freight transport is the main driver of the EU policies relevant to LDFT.

Specific drivers that the FREIGHTVISION project is concerned with are:

- The costs of road fatalities amounted to an estimated 2.5% of the EU's GDP in 2001. At the present rate, road fatalities are likely to stand at 32,500 in 2010.
- By 2020, road freight transport is expected to increase even more. Currently, congestion costs are estimated at around 1.1% of EU GDP per year.
- The energy dependency of the EU was 54% in 2006 and is expected to reach 70% by 2030. Transport accounts for 67% of the final demand for oil. The sector depends almost totally on the supply of fossil fuel products.
- Transport is responsible for more than one-fifth of greenhouse gas emissions.

5.2.1.2 Trends

Due to increasing environmental threats of road transport, efforts have been made especially for modal shift in transport, i.e., shifting LDFT demand from road to rail and inland waterways, and for the use of alternative fuels.

Infrastructure financing is an important trend in European policies relevant for LDFT. The attempts to extend the use of road charging to heavy good vehicles, which are mainly used for LDFT, is also a key trend to achieve a modal shift in freight transport for sustainability. Furthermore, legislations on the use of alternative (regenerative) fuels is becoming accepted.

The policies are also intended to achieving standardization of vehicles and their emission limits, implementing the use of technology in LDFT communication and simplifying administrative processes.

As regards safety, the emphasis has been on road safety measures.

5.2.2 National Policy

Kamil Krusina, Hans Zuiver and Julia Düh

National transport policies are embedded in EU transport policies (Fig. 5.1). Due to the subsidiarity principle governing the Union's project, national governments have nevertheless a broad margin for national policies where the EU does not regulate or where it sets minimum standards only.

The national transport policies focus on reliable, safe, and sustainable freight transport, while improving or maintaining the quality of life.

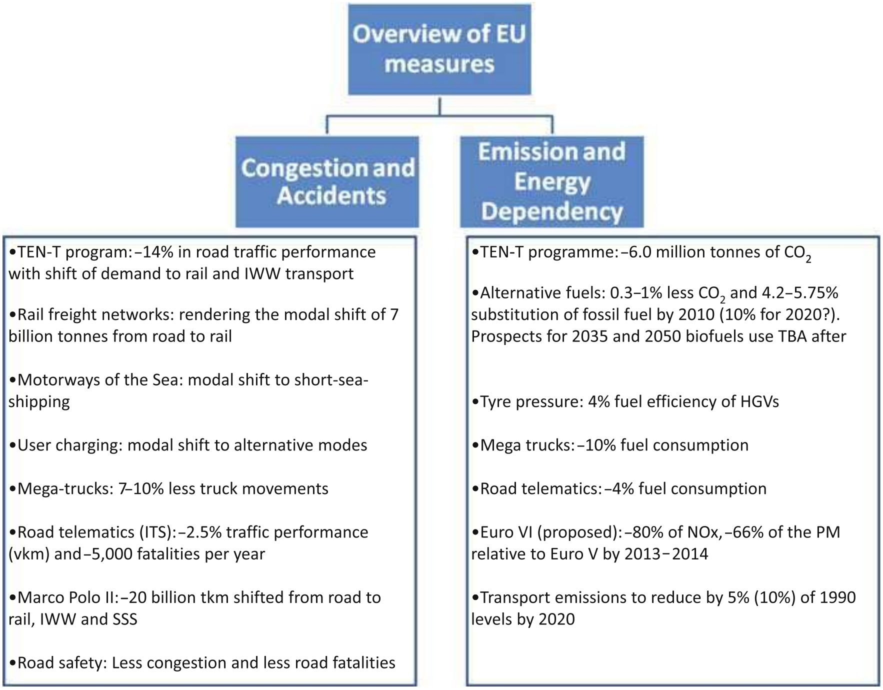

Fig. 5.1 Overview of transport policy measures

However due to the different geographic, economic, and financial situation, national policies' key drivers and trends differ between Member States. Countries with a high economic dependence on international trade (e.g. Denmark, Netherlands, Italy, and Spain) have a different focus than countries in environmentally sensitive areas in the centre of Europe (e.g. Austria).

Old Member States with high congestion (e.g. Netherlands, UK, France, and Germany) also have a different focus than new Member States with relatively low congestions (e.g. Slovakia, Romania, and Bulgaria). And last but not least, different infrastructure availabilities and financial capabilities have impacts on national policies.

5.2.2.1 Key Drivers

- *International competitive situation*. Member States strive to strengthen their international competitive position as much as possible. A smooth transport system and accessible main ports are considered an indispensable precondition for economic and social progress.
- *Infrastructure financing*. Due to budgetary restrictions Member States have to find new ways for financing their infrastructure.
- *Emissions*. In order to meet EU directives on air quality—and not risk penalties—Member States must reduce emission levels.

5.2.2.2 Trends

Probably the most important trend in the Member States (Fig. 5.2) is to improve the efficiency of every mode of transport. Every mode is required to handle the expected growth of freight transport in the coming years and to reduce road congestion. National polices therefore focus on smoothly functioning transport networks, in which road, rail, maritime, and inland waterways are all integrated.

The second strong trend is to promote rail and inland navigation as alternatives for road transport. Investments in rail and inland waterway infrastructure should lead to larger market shares, thereby reducing road congestion and limiting the negative impacts of transport.

The third trend is road pricing. Many countries already have a form of charges for heavy goods vehicles in the form of (electronic) toll collection or a vignette. The reasons behind this measure differ from country to country (funding of new infrastructure, tackling the negative effects of traffic, improving social development and accessibility). In The Netherlands, Denmark and the Slovak Republic road pricing for all vehicles will be implemented in the near future, while in other countries this is not the case. Promotion of sustainable transport is the final trend. While most Member States aim to substitute 5.75% of fuel use for land transport in 2010 and 10% in 2020 (in line with EU policy).

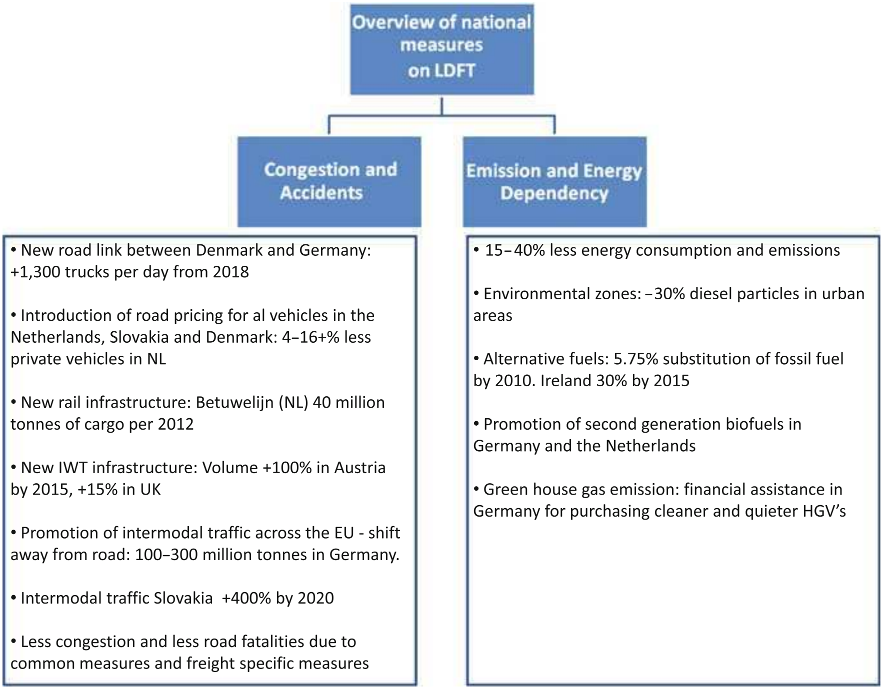

Fig. 5.2 Overview of national measures on LDFT

5.2.3 Key Demonstration Projects

Helena Kyster-Hansen, Michael Henriques, Hans Zuiver, Heidrun Rosič, Gerhard Bauer and Vit Malinovský

A large number of pilot projects on national and regional level have been identified as key demonstration projects. They could be widely implemented at EU, national and regional level through dissemination, investments, and complementary measures.

The FREIGHTVISION partners selected and described a number of pilot projects for road transport, short sea shipping, inland waterway transport, intermodal and rail transport.

5.2.3.1 Key Drivers

Key drivers for road transport are the focus on different equipments and measures for reduction of fuel consumption and reduction of the number of road fatalities with trucks involved, as well as introduction of modular haulage for optimization and reduction of the number of trucks on European roads.

Key drivers for short sea shipping and inland waterway transport are shifting from road transport and innovative measures such as double-stacking, innovative and optimized logistics, and operational systems.

For intermodal and rail transport, the shift from road onto rail is essential and key drivers are investments in reductions of different infrastructural and other bottlenecks, international coordination and cooperation between different stakeholders in the intermodal transport chain.

5.2.3.2 Trends

The measures to reduce energy consumption are as follows:

- eco-driving (10–14%),
- aerodynamic adjustments of spoilers etc. (10%),
- tire profiles and tire pressure (5–7%),

and hereby it is expected to reduce fuel consumption by 10–20% overall within the coming years.

The figures are estimates of maximum output for the specific measures on an individual basis, whereas an overall reduction of some 10% is expected in the coming years.

With modular haulage (25.25 m vehicle combinations) introduced throughout larger parts of Europe, less vehicles would be needed, the transport performance would increase by 1%, whereas traffic performance can be reduced by 12.9%, hereby giving positive effects for both safety and emission, and probably also for congestion through the reduced number of trucks.

For short sea shipping (SSS), the Motorways of the Sea (MoS) projects aim at shifting road volumes to ship and innovative measures; for example, double-stacking 45 feet loading units will lead to more than 50% reduction of CO_2 emissions and energy consumption by more than 50% on the Zeebrugge-Esbjerg route. Further MoS projects throughout Europe are expected to shift volumes from road to SSS, thereby reducing the number of trucks on the congested European roads and reducing energy consumption.

The inland waterways also have sufficient capacity for shifting road volumes and through innovative techniques; for example, some 185,000 truck rides can be avoided through the Waterslag project.

Combined transport (CT), i.e. rail, IWW, and SSS, on the long stretch and road for the local transport has further large potential for reducing road transport volumes. Through implementing measures proposed in the DIOMIS project as regards making the infrastructure more efficient, more infrastructure investments and international coordination, the unaccompanied CT will increase in volume by 113% to 268 million tonnes in 2015, (compared to 2005), and hereby reduce the energy consumption by 29% in the whole transport chain for these transports. At the same time the CO_2 emissions are reduced by 55% for these intermodal transport chains.

5.3 Technology Trends

5.3.1 Infrastructure Technologies and ITS

Arne Böhmann, Birger Hamisch, Christian Heinrich, Sylke Leonhardt, Vit Malinovský and Frank Panse

Main objective of Intelligent Transport Systems (ITS) and infrastructure technologies is to shape and use infrastructure in a more intelligent and hence more efficient and safer way. The main infrastructure technologies are as follows:

Road:

- Traffic control with VMS and temporary hard shoulder running
- Pre-trip and on-trip Information
- Collision avoidance
- Automated platooning

Rail (and Road-Rail CT):

- Rail freight corridors
- ETCS/ERTMS
- Integrated information platforms
- Reduction of noise emissions

Short-sea shipping and inland navigation:

- River information systems
- X-gate vessel tracking

5.3.1.1 Key Drivers

The key drivers for implementation of these systems are

- efficiency
- road fatalities
- congestion

5.3.1.2 Trends

Road:

- ITS services are currently widespread and future dissemination will grow, in the vehicles as well as on risky parts of motorways (congestion/road fatalities/bad weather). Up to 2050, the ITS services traffic control with VMS and temporary hard shoulder running are expected to be implemented wherever they are able to alleviate the road transport problems.
- Also pre- and on-trip information and collision avoidance systems will be diffused to almost maximum levels.
- Merely for the potential launch of automated platooning, further efforts and clarifications are needed.

Progress is also required regarding standardization of data and interfaces, further development of data transmission technologies (e.g. C2C and C2I), and improvement of traffic detection and weather conditions.

Rail:

- upgrade of current existing conventional freight networks,
- development of new rail freight corridors,
- upgrade of infrastructure for longer and heavier trains, and
- implementation of advanced technologies for interoperability (e.g. ETCS/ERTMS) and for noise reduction (e.g. new kinds of brakes).

These trends are also supported by the EC.

Short sea shipping and inland navigation:

- enhancement of ports and
- implementation of new technologies for vessels (e.g. RIS) and the management of cargo.

Road–rail combined transport:

Road–Rail Combined Transport (CT) is recognized as being the most dynamic market for freight transport in Europe. A transfer of loading units from road transport or in many cases maritime to road–rail CT diminishes the emission of pollutants and energy

consumption. Improvements in this sector are needed regarding the implementation of intelligent transport technologies which allow faster, more cost-effective, and reliable intermodal services.

Additional measures are

- use of new trans-shipment techniques on the current infrastructure,
- upgrade of existing terminals, or even
- construction of a new generation of terminals, opening a better perspective for CT

5.3.2 Engine Technologies

Martin Dirnwöber, Stefan Herndler and Gabriela Telias

The analysis provides an overview of engine and vehicle technologies as well as transport fuels implemented for freight transport and relevant to improve fuel economy and reduce GHG emissions.

The relevance of each mode[1] for freight transport in tkm in Europe is (Eurostat, 2007) (Table 5.1)

Road and waterways have by far the highest share with almost 40% each.

An important aspect regarding different modalities is their relative performance regarding energy efficiency (Dutch Inland Shipping Information Agency—BVB, 2008/2009, Table 5.2):

Modalities with big capacities are normally also the ones with the highest energy efficiency.

The main findings of the analysis are:

- Deployment of very efficient diesel propulsion systems running partly on biofuels seems to be the most likely development.
- Use of electric locomotives is supported by growing share of electrification in rail network (increase from 42% to 51% from 1992 to 2007).

Table 5.1 Modal split in tkm

Air	0.06%
Inland waterways	3.3%
Oil pipelines	3.4%
Rail	10.0%
Sea	39.1%
Road	44.2%

1 Air and sea: data only include intra-EU traffic and are estimates made by the Commission.

Table 5.2 Energy efficiency of transport modes

Type of transport	Average cargo capacity (tonnes)	Primary energy consumption (MJ/tkm)
Road		
Van–petrol	0.9	11.42
Van–diesel	0.9	11.48
Van–LPG	0.9	10.96
Lorry	7.3	4.06
Lorry & trailer	19.3	1.82
Truck & trailer	25	1.4
Inland navigation		
International	1,250	0.43
National	700	0.48
Rail		
Electric traction	1,000	0.59
Diesel–electric traction	650	0.73

Deployment of propulsion systems relying on batteries or fuel cells appears to be unlikely in long-haul freight transport. This would be possible only if major obstacles are overcome (e.g. low energy density, infrastructure, low durability).

5.3.2.1 Key Drivers

The key drivers for the introduction of alternative technologies are:

- environmental policies and
- energy costs.

5.3.2.2 Trends

- The main trend in every mode of transport is the continuous reduction of fuel consumption through improved efficiency.
- Diesel engines for road transport are expected to increase their efficiency by up to 20% beyond 2020.
- The current trend of electrification of railway tracks will continue.
- Diesel fuel produced from conventional and unconventional resources will be increasingly implemented in the short term. Deployment of synthetic diesel fuels from coal and natural gas seems likely in the mid term. Biofuels used in diesel engines will have a limited share with a possible increase in long-term.
- Use of cleaner fuels especially in inland navigation and short sea shipping.

5.3.3 Logistics Technologies

Werner Jammernegg, Florian Kressler and Heidrun Rosič

Logistics technologies can be divided into software and hardware technologies.

Software technologies, so-called Advanced Planning Systems (APS), are software packages that support decision-making in a supply chain context, such as decisions about the location of production or distribution sites, distribution plans, the choice of a certain mode etc.

Concerning hardware technologies, Global Navigation Satellite Systems (GNSS) and Radio Frequency Identification (RFID) are covered. With a GNSS receiver, the current position of an object (e.g. vehicle, container,...) can be identified. In freight transport the main fields of application of GNSS are the optimization of route planning, improved reaction to unforeseen events, and better use of available cargo space.

With RFID it is possible to send data contactless and without line-of-sight. RFID technology is already used to some extent in logistics processes, e.g., in warehousing for the quicker identification of objects or for the backtracking of products.

5.3.3.1 Key Drivers

Industrial companies face the challenge to constantly optimize their operations and reduce cost in order to stay competitive in the market. Furthermore, they have to cope with an increasing complexity of supply chains due to globalization. APS help to manage these complex supply chains and to reduce the total cost. Recent studies have shown that with the help of APS,

- average freight distance can be shortened by 20% and more,
- number of trips can be optimized, and
- utilization of vehicles can be increased.

Thus, logistics cost can be reduced on average by 15–20%.

The need to have up-to date information as to where vehicles and even individual products are located is continuously growing.

Besides, information concerning the state of a product (e.g. temperature) is very important. Logistics technologies such as GNSS and RFID help to provide this information.

5.3.3.2 Trends

- In 2002, a survey showed that APS have been implemented by almost 50% of the companies interviewed.
- In 2007, the revenues of the total APS market amounted to nearly 6 billion US$ which represented an increase of 17% compared to 2006 (Table 5.3).

Table 5.3 Revenue and market share 2007 of selected APS vendors

Company name	2007 revenue (in million US$)	2007 Market share (%)	Growth 2006–2007 (%)
SAP	1,334.4	22.4	31.9
Oracle	955.2	16.0	26.1
JDA Software	229.6	3.9	67.4
Ariba	160.3	2.7	6.3
Manhattan associates	152.2	2.6	13.0
Others	3,313.5	52.5	8.8
Total	5,963.2	100	17.6

Source: Gartner Inc. (2008)

The market is estimated to grow by 7% annually until 2012, therefore reaching a much higher degree of diffusion than today.

- But, as long as the costs of implementation remain high, small and medium-sized companies will not be able to afford APS.
- It can be expected that in the medium-term future, satellite navigation information will be considered an essential part of the infrastructure. It is assumed that until 2020 GNSS will be an integral part of our daily lives.
- Besides its use for navigational purposes, GNSS will be used in other applications in the freight sector, most notably in connection with intelligent containers.
- RFID will follow the same development, although at a slower pace.
- The next step is the integration of all the different types of information in an APS for optimal planning, control, and management of logistics networks.

5.4 Demand-Related Mega Trends

5.4.1 Socio-Economic Trends

Natalia Anders, Franziska Knaack, and Stefan Rommerskirchen

The objective is to elaborate long-term quantitative trends of freight transport performance for 30 European countries (EU 15, EU 12, Switzerland, Norway, Croatia), based on socio-economic trends (population, GDP, foreign trade etc.).

5.4.1.1 Key Drivers and Their Impact on Freight Transport Demand

The patterns of future development of *population* in EU countries are diverse. New Member States will experience significant losses, whilst some of the old Member States

will have an increasing population. A certain shift of transport demand from Eastern to Western Europe is therefore to be expected for general demographic reasons.

Key drivers of freight transport demand have always been the progressing *spatial division of production*. This will remain true but change with regard to transport distances.

While in the past, division of labor was a local or national trend mainly, since about 30 years it becomes more and more a European and even global phenomenon with respective foreign trade developments. For the future, it is expected that labor division as well as the foreign trade will continue to globalize.

The analyses of the origin of GDP by industry show the current and continuing great importance of the manufacturing industry, but also a big and increasing role of the service sector as a whole.

Comprehensive analyses show that intra-European trade is of much more importance today than intercontinental trade.

GDP growth does not show the big dynamics of foreign trade development, since foreign trade is growing at a significantly higher level than GDP.

5.4.1.2 Trends

- In general, the annual growth rates of all mode freight transport performance in all study countries decrease up to 2050, but they will not be negative for most countries.
- The biggest increase of all mode transport performance as percentage change will take place in Croatia, Austria, Slovenia, and Romania.

In absolute figures, the biggest increase will occur in Germany, Spain, and France, in particular due to the country size and also due to the countries' location (especially Germany and France).

- Roughly one-third of the total transport performance in the Western European countries is produced on German territory (where the growth is expected to be 89% from 2005 up to 2050). France follows with a share of 21%, Italy and Spain of 13% in 2005 with an increasing trend. The new Member States combined have a share of 14%.
- Because of stronger economic development in the next years, a substantial increase in total transport performance can be expected up to 2020. Poland has the largest weight of all 12 new EU Member States (including candidate Croatia) with a share of 25% (Table 5.4).
- Generally, the growth in all 30 countries is much higher in international transport (export, import, transit) than in national (domestic) transport.
- The modal share for road transport in the past is quite important in the EU 15, Switzerland and Norway. For 2050, a decreasing road transport share is estimated for almost all Member and Accession States (Table 5.5).
- The modal share of rail transport is quite important and will remain important in 2050 for Switzerland and Baltic countries. Over all countries, an increase of 3% is estimated for 2050.

Table 5.4 Growth rates of land transport performance (national, international, total)

Countries	2005 in billion tkm	05–20 in %	05–35 in %	05–50 in %	05–20 in p.p.a.	20–35 in p.p.a.	35–50 in p.p.a.
Growth rates of national transport performance							
EU27	1,494.6	27	38	42	1.60	0.55	0.19
EU15+CH, NO	1,324.3	26	38	43	1.55	0.60	0.23
EU12+HR	206.3	33	38	36	1.91	0.23	−0.05
All 30 countries	1,530.5	27	38	42	1.60	0.55	0.19
Growth rates of international transport performance							
EU27	820	46	71	88	2.57	1.06	0.63
EU15+CH, NO	710.5	42	66	82	2.38	1.03	0.62
EU12+HR	128.5	71	105	126	3.65	1.20	0.65
All 30 countries	839	47	72	89	2.59	1.06	0.63
Growth rates of total transport performance							
EU27	2,314.5	34	50	58	1.95	0.75	0.37
EU15+CH, NO	2,005.9	32	48	57	1.86	0.77	0.38
EU12+HR	334.7	48	63	71	2.63	0.68	0.3
All 30 countries	2,340.6	34	50	59	1.98	0.75	0.37

Table 5.5 Modal share trends for transport performance (road, rail, inland waterway)

Countries	1995	2000	2005	2007	2020	2035	2050
Modal shares of road transport performance (in %)							
EU27	79.7	82.4	83.8	83.8	84.5	82.7	80.4
EU15+CH, NO	85.2	85.8	86.8	86.5	86.7	85	82.9
EU12+HR	49.3	59.6	64.8	66.7	71.6	68.2	63.9
All 30 countries	79.7	82.4	83.8	83.8	84.5	82.8	80.4
Modal shares of rail transport performance (in %)							
EU27	17.8	15.2	13.9	14.1	13.3	15	17.1
EU15+CH, NO	12	11.7	10.9	11.3	11.1	12.6	14.6
EU12+HR	49.8	39	33.8	32.2	27.2	30.2	34.2
All 30 countries	17.8	15.3	14	14.2	13.3	15	17.1
Modal shares of inland waterway transport performance (in %)							
EU27	2.6	2.4	2.2	2.1	2.2	2.3	2.5
EU15+CH, NO	2.8	2.5	2.3	2.2	2.3	2.4	2.6
EU12+HR	1.2	1.4	1.4	1.1	1.2	1.5	1.9
All 30 countries	2.5	2.4	2.2	2.1	2.1	2.2	2.5

- Inland waterway transport plays currently an important role in the Benelux countries and in Germany. Up to 2050 inland waterways will not increase their market shares significantly as a trend.

The presented transport demand forecasts are based on data and information available up to December 2008. At that time no quantitative information about the upcoming financial and economic crisis and their impacts on freight transport demand was available. The crisis caused a strong negative variation from long-term trends. We are nevertheless convinced that this trend variation remains a short-term effect. Considering that the long-term trend forecasts include the assumption of long-term decreasing growth rates already, there is no need at this point to revise the provided long-term forecasts for the years 2020, 2035, and 2050.

5.4.2 Congestion Trends

Jeppe Rich and Christian O. Hansen

The overall objective is to assign transport demand to the existing and planned transport network to estimate congestion and other network effects. Congestion is a major obstacle for economic growth, efficient trade, and competitive economies.

The reference backcast measures the most likely development given the assumptions put forward. Reference backcasts have been made using the TRANS-TOOLS model developed in the TENconnect study.

5.4.2.1 Key Drivers

The key drivers influencing transport demand and thus congestion in the TRANS-TOOLS model are

- *GDP growth* (see Sect. 5.4.1)
- *Infrastructure development*. Rail and road infrastructure is updated according to projects that are already planned or decided.
- *Transport cost estimates for rail*. A decrease of 10% in the average transport costs is anticipated. The decrease is due to more efficient planning and improved interoperability.
- *Transport cost estimates for road*. Transport operating cost for trucks is expected to increase by 4% in 2020/2030 compared to 2005 in fixed prices. This includes a general cost increase of 20%, which is partly offset by improved logistical operations. Toll costs are added and follow the proposal for the revision of the Vignette directive of 0.067 EUR per vehicle-km in rural areas and 0.15 EUR per vkm in urban areas.

5.4.2.2 Trends

Road congestion:

The current European road and congestion profile can be characterized by

- Eastern Europe, Balkan, Turkey: Low congestion
- South and Northern Europe: Medium congestion
- Central Europe and UK: High congestion

As can be verified from Fig. 5.3, there is a non-linear relationship between travel time and flow, which implies that high congestion regimes are relatively more sensitive to traffic growth. It means that even relatively small increases in traffic volumes in central parts of Europe and UK may have significant congestion effects.

- The TRANS-TOOLS model projects a moderate road traffic growth in Central Europe, whereas a more aggressive growth is expected in Eastern Europe, Balkan, the Baltic countries, and Turkey.
- At the European level, congestion is expected to rise through 2020 and 2030 from its current level. The increase will be highest in Central Europe in that the present high level of congestion will cause the moderate increase in traffic to have a relatively large

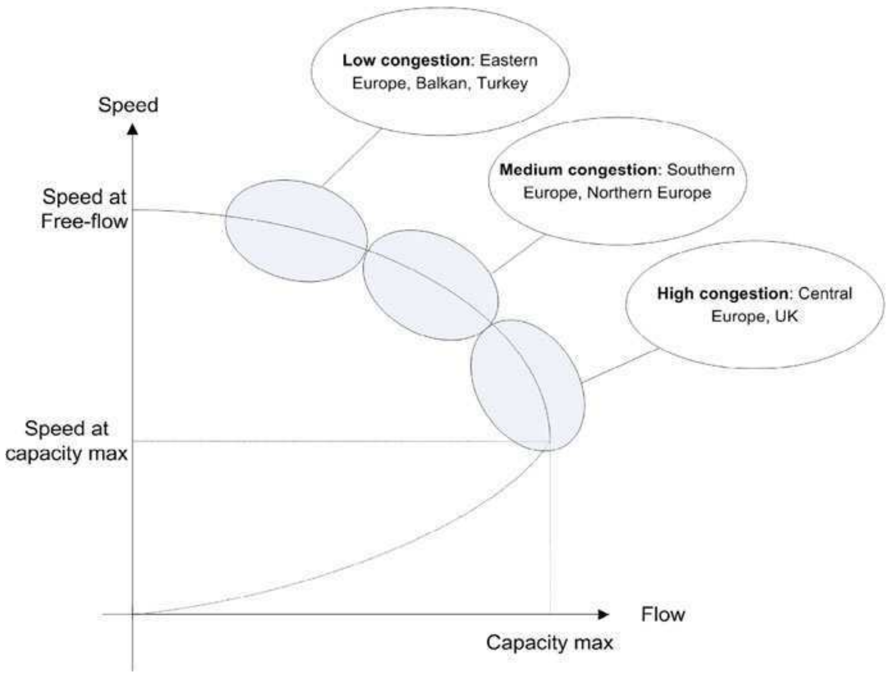

Fig. 5.3 Congestion profile for European regions

impact. For Eastern Europe, where we have a low present congestion level but expect a relative high traffic growth, a more modest increase in congestion is expected. In other words, the increase in traffic is largely absorbed by free capacity.
- Road bottlenecks are primarily located around the large cities (Fig. 5.4). In particular the London-Manchester-Birmingham triangle, the Ruhr district, and Northern Italy (Milano). France, Spain, Scandinavia, and Eastern Europe will experience a slower increase in congestion.

Rail congestion:

It is expected that rail transport performance (measured in tkm) will increase relatively to road transport. More specifically, we anticipate

- longer trips due to market specialization,
- shift from national to international transports, and
- growth in specific bulk corridors to Russia.

The impact in terms of congestion cannot be explicitly represented in the TRANS-TOOL. However it is expected that

- due to longer trips, rail transport will be more sensitive to bottlenecks in agglomerations, and
- the general increase in rail demand (for passengers and freight) will put pressure not only on the network but also on terminals and re-loading centers, which may increase waiting times.

Inland waterways:

Inland waterways are not expected to be affected by congestion and the transport growth is assumed to be absorbed by free capacity.

5.4.3 Emission Trends

Riina Antikainen, Anne Holma and Frank Panse

Transport has been identified to be one of the main causes of various environmental problems:

- Climate change is most likely the most important of these needing urgent mitigation measures; and therefore, the main emphasis has to be given to this aspect.
- Atmospheric emissions causing acidification and tropospheric ozone formation are other aspects needing attention.
- Additionally, transport may cause significant health impacts, especially in densely populated areas due to particulate matter emissions and noise.
- Exhaustion of natural resources, such as fossil fuels and soil, is another challenge faced by the transport sector.

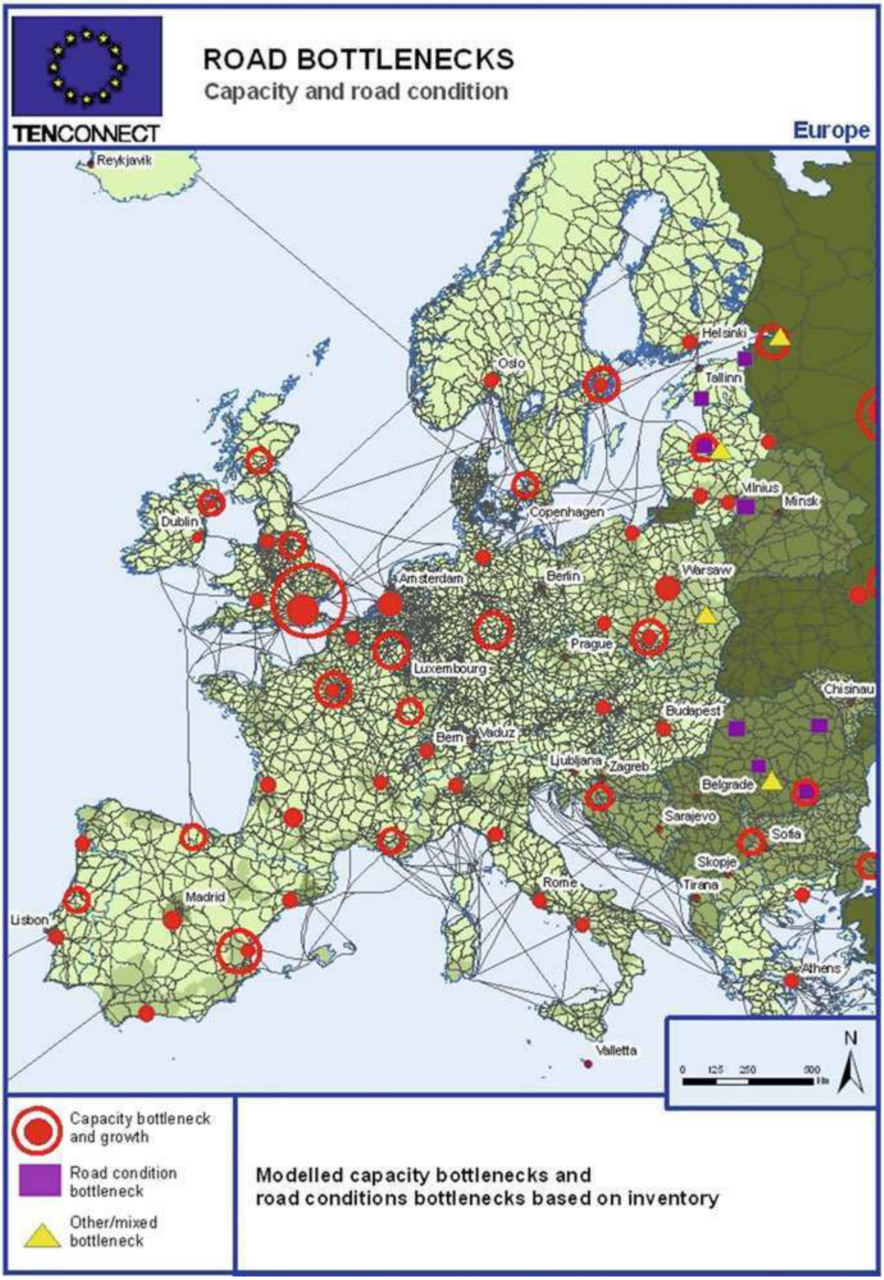

Fig. 5.4 Overview of European road bottlenecks

- Loss of biodiversity due to habitat loss, degradation and fragmentation, and introduction of foreign species may significantly reduce ecosystems' capacity to resist pressure.

Relatively little information is available relating to the freight transport's environmental problems, and therefore when data is not available, a wider perspective on transport as a whole is taken.

5.4.3.1 Key Drivers

Key transport-related drivers affecting the environmental aspects include:

- transport volume,
- modal split,
- technology type and development state,
- fuel type, and
- fuel consumption or energy efficiency.

In a wider perspective, key drivers' denominators of future emissions and resource use include drivers such as consumer behavior, globalization and relocalization, and energy (oil) prices. Demand of greener or less goods may reduce the need for transportation if more local products are preferred. It can also mean that more services are consumed instead of transport-intensive goods. If the past trend of globalization continues, it is likely to increase transport volumes and therefore also environmental impacts, if technological development and change in modal split will not compensate growing volumes. A counteraction for globalization may also be relocalization, production, and consumption of goods closer to each other. This may reduce (very) long-distance transportation, but the impacts on emissions are not clear. Low energy prices and especially low oil prices do not favor development and introduction of less emission-intensive fuels and technologies.

5.4.3.2 Trends

The energy use and the associated carbon dioxide emissions from freight transport grew faster than in almost any other sector between 1995 and 2005. According to EU statistics (EC 2006), inland freight transport performance (road, rail, and inland waterways) in EEA member countries increased by 30% (2.6% per annum) during this time period. Despite the decline in overall energy intensity of freight transport, it is estimated that in OECD countries, the energy consumption by freight transport will continue to grow (on average by 1.1% per year,) between 2005 and 2030 (EIA 2008).

The oil dependency of the transport sector in relative terms is expected to some extent to be moderated by the penetration of biofuels and other alternative fuels in road transport.

However, in absolute terms, the total consumption of oil products in road transportation is projected to continue to grow at least up to the year 2030 in the EU.

Worldwide growth in use and dependence on petroleum fuels is expected to continue beyond 2050.

Transport emits atmospheric pollutants also other than greenhouse gases, most importantly SO_2, NOx, NMVOCs, CO, and particulate matter. Abatement measures to reduce these emissions have been more successful than in the control of GHGs, and transport-related emissions of these substances have decreased by about 30–60% since 1990.

However, there is still a need of further reductions in order to meet the 2010 targets of the National Emission Ceilings Directive and the urban air quality guidelines. For SO_2 emissions, maritime transport is critical.

Little information on the role of freight transport in the trends of noise emissions of transport equipment, use of soil as a resource, and biodiversity losses is readily available. In any case, it is well acknowledged that transport, and especially road transport has a significant negative impact on them, and therefore it is anticipated that as a consequence of growing transport volumes, a negative trend in these aspects will be witnessed.

5.4.4 Energy Trends

Nikos Kouvaritakis, Leonidas Mantzos, Vangelis Panos, Panagiotis Fragos and Nikolaos Tasios

The aim of this task is to examine key trends in the broader energy system, with particular emphasis on these factors within it that are likely to influence energy demand for freight transport. The methodology for the analysis has concentrated on quantitative aspects, using two large scale models developed and maintained by E3M-Lab of ICCS/NTUA: the PRIMES energy model for Europe and the PROMETHEUS stochastic energy model for analyzing alternative prospects at the world level.

5.4.4.1 Key Drivers

Future energy demand in the freight sector of the EU will be primarily driven by the following factors:

- The evolution of overall freight transport activity which is itself dependent on the pace and composition of economic growth.
- Intermodal shifts that can influence the type of fuel used and overall energy efficiency.
- Technological improvements including the development and diffusion of radically different technological options.
- Policy interventions such as taxation, fiscal incentives, and the development of different types of infrastructure in an effort to promote sustainability in freight transport.

The drivers above primarily depend on developments and actions within the frontiers of the European Union.

- Another key driver is the future course of fuel prices, in particular oil prices, since petroleum currently overwhelmingly dominates transport energy.

5.4.4.2 Trends

- Despite lower growth in both advanced and emerging economies, the median growth of the world economy to 2050 will be very close to that experienced in the last four decades, as a result of the increasing weight of emerging economies. Under such conditions median oil prices in 2050 will be close to 2008 averages.
- If the developing World grew on average close to historical rates, the probability of exceeding 2008 levels increases to more than two-thirds.
- Under current geological assessments, the probability of obtaining such high prices is around 75%.
- According to the Baseline projection, there is a 40% probability that world conventional oil production will peak before 2020.
- On the other hand non-conventional petroleum is very likely to compensate substantially: by 2050 there is a 40% probability that tar sands, extra-heavy oil, and schist will satisfy more than 50% of world demand.
- An alternative pattern of mobility to the horizon of 2050 is very unlikely. Currently the transport sector absorbs around 50% of total world oil demand. According to the baseline, there is 78% probability that this share will exceed 60% by 2050.
- Important savings (more than 10%) in oil demand could be achieved assuming a concerted R&D effort on alternative road transport technologies and fiscal supports to promote them. However in such a case most of the impacts would be felt beyond 2040.
- Freight activity (excl. air freight) which is currently growing at rates close to economic growth is projected to decelerate faster than the latter especially in the longer term. Even by 2050 it will however be still dominated by trucks. Specific energy demand for freight transport will decline by more than 30% between 2005 and 2050 due to technological progress.
- High or very high oil prices could provide a necessary stimulus for the transformation of the transport energy scene. Oil prices are however volatile and surrounded by considerable uncertainty in the short as well as the longer term.
- Improvements will be less pronounced for road freight and particularly dramatic for rail freight due to the projected completion of the electrification process already by 2030.
- Transformation of the road transport sector toward hydrogen use is deemed to be extremely unlikely in the projection horizon. However assuming a massive R&D, infrastructure development, and fiscal supports, significant break-throughs could be achieved after 2040.

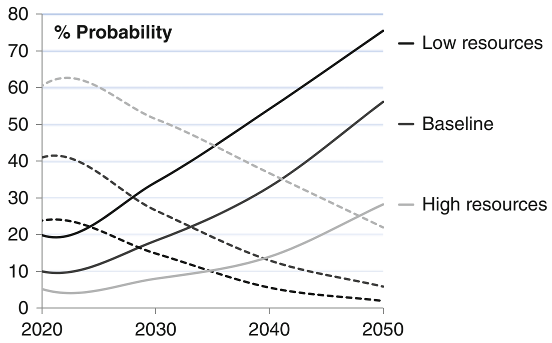

Fig. 5.5 Impact of resources on oil price

- There will be sufficient low-carbon or carbon-free options for producing the hydrogen, and they could dominate supply even in the context of a moderate abatement policy.

For three alternative geological probability assessments of undiscovered hydrocarbon resources, Fig. 5.5 shows the probability that

- oil price exceeds September 2008 level of 100 USD (2005) per barrel (solid lines).
- oil price is lower than 2005 level of 55 USD (2005) per barrel (dotted lines).

5.4.5 Logistics Trends

Heidrun Rosič, Gerhard Bauer and Werner Jammernegg

Within international networks of production companies, logistics trends have a huge impact on transport demand. In logistics networks, besides transportation other activities, such as sourcing, production, and warehousing, are necessary in order to fulfill the requirements of final customers.

5.4.5.1 Key Drivers

Traditionally, the design of a logistics network is based on financial objectives, i.e., minimizing total logistics costs which consist of

- facility costs,
- inventory costs, and
- transportation costs.

There is a basic trade-off between

- economies of scale and
- responsiveness by being close to the market.

In addition to the financial objectives, a wide variety of other factors influence the network design and therewith the location of facilities.

Concerning the facility location, also

- macro-economic factors,
- quality and cost of labor,
- availability of infrastructure and manufacturing, and
- logistics technology

have to be considered.

5.4.5.2 Trends

Prevalent logistics trends are:

- outsourcing (to subcontract a process to a third party which can gain economies of scale),
- offshoring (dislocation of a production activity to a far-distant country in order to lower operational costs), and
- centralization (to reduce the number of production, procurement or distribution sites; to pool risk, reduce inventory, and exploit economies of scale).

The resulting design of the logistics network is mainly based on a cost perspective. For instance, offshoring leads to a reduction of total logistics costs by 25–40%. But important "soft" factors, like delivery time, flexibility, and risks of a logistics network can lead to a considerable reduction of this cost advantage.

Furthermore, stricter regulations and increased awareness of customers with respect to the environment support a reconsideration of a company's strategy.

All prevalent logistics trends usually result in increased transportation distances. In this respect, resulting risks (road fatalities, congestion) as well as environmental aspects (dependence on fossil fuels, CO_2 emissions) should be considered.

Thus, from an integrated perspective, including costs, risks, and environment, new logistics trends become more important (Table 5.6). By moving production activities closer to the market through

- nearshoring,
- onshoring, or
- decentralization,

the transportation distances can be reduced, and therefore network redesign can have a positive impact on the key indicators, especially on CO_2 emissions.

By using a flexible supply base, a company can benefit from low costs in an offshore facility and simultaneously be able to respond quickly to demand fluctuations by serving the market also from an onshore site.

In this way, the amount of long-distance freight transport can be reduced, therefore mitigating transportation disruptions, such as road fatalities and congestion.

Furthermore, flexible transportation helps to improve the performance of a logistics network with respect to the key indicators by a change of transport mode, multi-modal transportation, or the use of multiple routes.

Improvements in transportation efficiency, such as better vehicle utilization and reduction of empty trips, again leads to a reduction of the number of transport movements. Thus costs, CO_2 emissions, and fossil fuel consumption can be reduced significantly (Table 5.6).

Table 5.6 Overview logistics trends

New logistics trends –Integrated perspective	Characteristics	Relevance for key indicators	Case study
Network redesign	Nearshoring, onshoring, and decentralization	Reduced transportation distances and number of transport movements	Using regional distribution centers, a company from the metal manufacturing industry was able to reduce the average distance to the customer by 46%. In the apparel industry, the decision to produce at an onshore facility reduced CO_2 emissions by 25%.
Flexible supply base	Using multiple supply sources (offshore and onshore)	Reduced number of long-distance transport movements and mitigation of transportation risks (road fatalities and congestion)	Hewlett Packard uses an offshore facility to produce the base volume and employs also an onshore facility to quickly react to disruptions and demand fluctuations.

Table 5.6 (*continued*)

New logistics trends –Integrated perspective	Characteristics	Relevance for key indicators	Case study
Flexible transportation	Change of transport mode; Multimodal transportation; Multiple routes	Reduced CO_2 emissions and dependence on fossil fuels Reaction to occurrence of risk events (road fatalities and congestion)	LKW Walter saved 1,211 km per shipment by changing the mode (1,523 km on the road vs. 312 km short sea/trucking), in total over 1.2 million vkm per year.
Transportation efficiency	Vehicle routing and loading	Reduced number of empty trips	By maximizing full truck load, PepsiCo, on average, saved 1.5 million vkm and 1,200 tonnes of CO_2 emissions.
	Consolidated shipments	Improved vehicle utilization	A manufacturer of household and personal-care products cut fuel use by 630,000 liters by combining multiple customer orders.

5.5 Conclusions

The presentation of the key drivers in this chapter follows the structure of the FREIGHTVISION project as outlined in Sect. 1. This does by no means suggest an order of importance.

The first and maybe the most influential key driver for long-distance freight transport is *freight transport demand*. The indicator for freight transport demand is the EU27's total transport performance (in tkm). The trend development of EU27's total transport performance is expected to be a 58% growth between 2005 and 2050. This growth rate includes both national and international transport; whereas due to an increased labour division, international transport performance growth is expected to be about twice as high as national.

From a microeconomic perspective, the increased labour division is reflected by the dominant *logistics trends* of recent years. These trends driven by financial objectives

were outsourcing (subcontracting to 3rd parties), offshoring (dislocation of a production activity to a far distant country), and centralization (reduction of the number of production procurement or distribution sites). From a transport's perspective, all of these trends resulted in increased transportation distances as production activities were moved further away from the market. In the future stricter regulations, transport risks, carbon pricing, and increased customer awareness on GHG emissions might lead to network redesigns, where new logistics trends like nearshoring, onshoring, or decentralization could become more important. But nevertheless as the trends of the latest years were caused by substantially reduced logistics costs, a change in trend will be unlikely to occur, if logistics' costs are unchanged.

One of transport's key drivers with impact both on logistics' risks and costs is the *availability of fossil fuels*. The projection is that the median oil price in 2050 will be close to the average in 2008, which was extremely high. For this trend forecast, it was assumed that the median growth of world economy until 2050 will be very close to that experienced in the latest four decades. But if the developing world grew on average close to historical rates, the probability of exceeding 2008 levels would increase to more than two-thirds. Regarding energy availability, the analysis' result is that there is a 40% probability that world conventional oil production will peak before 2020. But on the other hand, non-conventional oil is very likely to compensate this substantially: By 2050 there is a 40% probability that tar sands, extra-heavy oil, and oil shale will satisfy more than 50% of world oil demand.

Transport costs for road (tkm) are expected to increase by 4% until 2030. This increase takes into account higher toll costs and a general cost increase, which is partly absorbed by increased logistics efficiency by 20%. Transport costs for rail are anticipated to decrease by 10% until 2030. The decrease is due to more efficient planning and improved interoperability. Transport costs, competitiveness, and longer transport distances due to the above-mentioned increasing labour division will lead to a modal shift to rail.

Another key driver is *infrastructure capacity*. The development of population and economic growth is expected to vary a lot between European countries. Therefore the growth of transport demand and thus demand for infrastructure will differ between regions. The increase of congestion is expected to be highest in Central Europe, where road bottlenecks are primarily located around the large cities. For Eastern Europe, the increase in traffic will largely be handled by available capacity.

One key driver to cope with infrastructure capacity limitations and thus using infrastructure more efficiently is the usage of *information technologies*. This trend is visible in all three modes and both for infrastructure operators and infrastructure users/vehicle suppliers. For road these technologies are, e.g., traffic control with variable message signs, temporary hard shoulder running, pre- and on-trip information, collision avoidance, or automated platooning. For rail the main technology trend in this respect is the implementation of Electronic Train Control System (ETCS) /European Rail Traffic Management System (ERTMS). From a logistics operator perspective, the main trend in information technologies is the implementation of Advanced Planning Systems, which are software packages that support decisions in a supply chain context, such as

decisions about the location of production or distribution sites, distribution plans, or the choice of a certain mode. Another relevant trend in this area is the increased usage of Global Navigation Satellite System (GNSS) and Radio Frequency Identification (RFID) systems, which will be increasingly used on not only the truck but also container level ("intelligent containers").

The second technological key driver besides information technologies is *engine technologies*. The most important engine technologies' trend is that diesel engines are expected to increase their efficiency up to 20% until 2020. As the deployment of propulsion systems relying on batteries or fuel cells appears to be unlikely in long-haul freight transport, the deployment of very efficient diesel propulsion systems running partly on biofuels seems to be the most likely development, although the sustainability of especially current biofuels have been questioned. In rail the current trend of electrification of railway tracks will continue and thus supports the use of electric locomotives.

Policy is another key driver. European Union policy is based on free trade (increased openness of the Member States) and EU enlargement. On European level infrastructure financing, liberalization and standardization are important trends in European policies relevant for long-distance freight transport. Due to increasing environmental threats of road transport, efforts have been made for modal shift to rail, inland waterways, and short sea shipping. Recently the term "co-modality" was introduced, to emphasize that no mode should be prioritized, but each mode should try its best to become sustainable. The EU recently confirmed its 20-20-20 strategy,[2] but no target for freight transport has been specified. External costs can be internalized, but only at a certain level, and it is still under discussion, if this definition includes all external costs.

Finally the maybe strongest key drivers in the future will be *GHG emissions* and *climate change*. While in the past transport's legislation with regard to emissions focused on a reduction of SO_2, NO_x, NMVOC, and particulate matter, there is shift to GHG emissions abatement expected—also for freight transport. If climate change comes into effect as expected in recent Intergovernmental Panel on Climate Change (IPCC) reports (IPCC 2007), then there will be also direct effects on infrastructure availability and indirect effects via socio-economic development and transport demand.

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6 Forecasts

Jürgen Schmiele, Tuomas Mattila, Riina Antikainen, Christian O. Hansen, Jeppe Rich, and Ulrich Glöckl

Abstract FREIGHTVISION uses business-as-usual forecasts to quantify the changes of suggested measures. This chapter defines the assumptions that have been set for three possible futures: a low forecast with optimistic assumptions such as Carbon Capture and Storage (CCS) will work very soon, a trend forecast that assumes only little changes compared to today, and a high forecast when technologies fail to deliver its promises. In all forecasts the reductions are too little to meet the Visions set from Chap. 7. The results of the forecasting approach is that for the majority of the indicators and timestamps the gap between where we would like to be at and where we are likely to be at continues to widen. This applies even for the low forecast, which is comparably optimistic on the improvement of truck engines, continuously increasing average load factors and other technology driven possibilities.

6.1 Introduction

The goal of FREIGHTVISION's forecast development is to show a range what the future might bring, if policy makers and market players move ahead as they have in the past. All forecasts are business-as-usual forecasts, where fundamental behavioral changes do not occur. Technological progress and improvements however are included.

Future uncertainty is addressed by using three different forecasts.

- a trend forecast consisting of the most likely development,
- a low forecast, which combines positive developments that result in easier mitigation, and
- a high forecast that describes a future, in which it is more difficult to mitigate than in the other two forecasts.

When using a low and high forecast, a bandwidth of possible developments is being sketched. The trend forecast is positioned between the upper and lower limit and is

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the most likely development based on the knowledge that we possess today. For the reasoning of high and low forecasts, it has to be kept in mind that various parameters may change slightly differently to our trend forecast. They are not fully consistent, but they are deemed to be plausible and possible.

Forecasts have been developed with all four sustainability criteria in focus. In this chapter the assumptions relevant for all four forecasts are described:

- Freight transport demand,
- Modal split, and
- Average load.

Additional assumptions relevant for each criterion are described in the respective sections.

Freight Transport Demand

Freight transport demand was evaluated using data published in Deliverable 4.1 by ProgTrans AG, Basel (Switzerland). Therein the growth in freight demand by country is projected and the development of the modal split is estimated. This information has been aggregated for the EU27 until 2050.

Figure 6.1 shows the three forecasts in terms of freight transport demand in tkm for the EU27 (Anders et al., 2009).

Modal Split

For all three forecasts, the same modal split is assumed (Fig. 6.2).

Freight transport demand changes over time slightly in favor of rail and IWW. The relatively small change in the modal split is due to the immense dominance of road freight, despite higher growth rates in particular in the rail freight sector. Rail freight transport is projected to grow disproportionally in particular after 2020. Inland waterways will grow below the according figure for road transport until 2035, but will surpass the growth rate of road by 2050.

Average Load

In order to calculate the number of vehicle kilometers needed to haul the amount of goods projected on Europe's roads, it is necessary to estimate the average load. This value varies tremendously among European countries, commodity groups, and the distances traveled.

Since reporting empty runs is optional, some countries do not report it. In order to develop vehicle km estimates, different likely assumptions had been made on the average load in LDFT for the EU27 (Table 6.1).

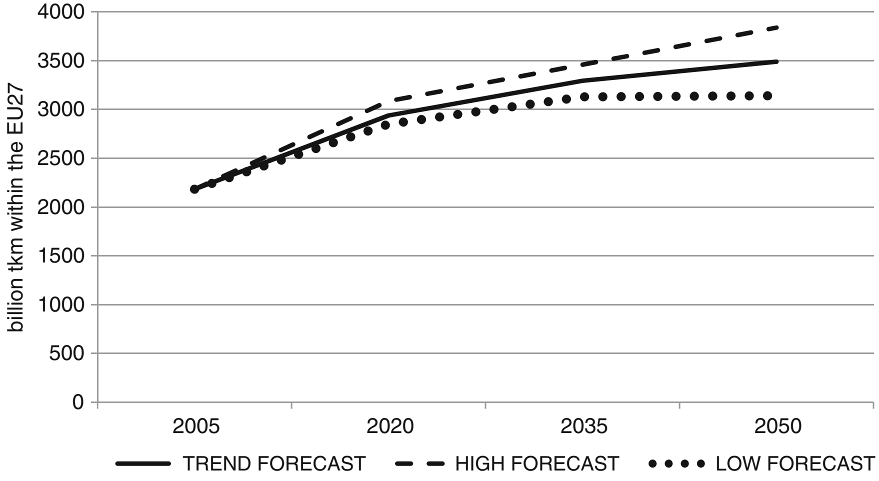

Fig. 6.1 Development of tkm for all modes within EU27 (LDFT). Source: Anders et al. (2009)

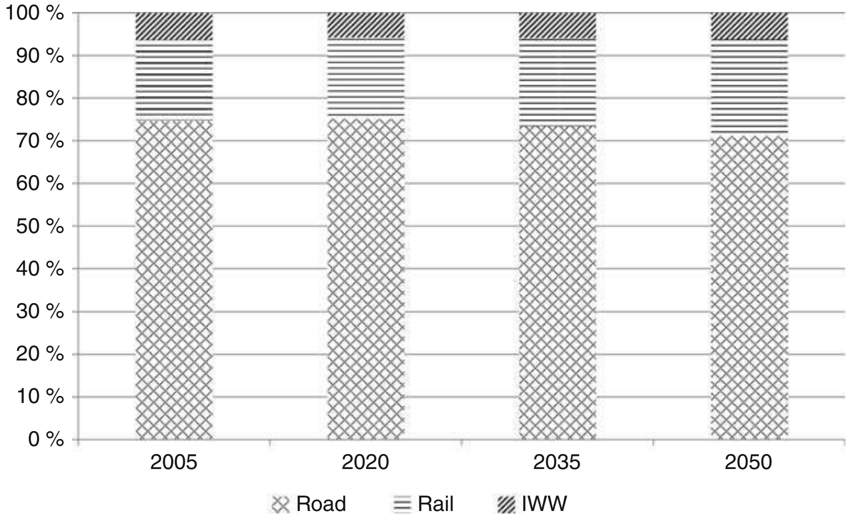

Fig. 6.2 Development of modal split in LDFT. Source: Anders et al. (2009)

Table 6.1 Development of average load (incl. empty runs) in the forecasts for EU27

	2005	2020	2035	2050
Trend forecast	9.81t	10.3t	10.7t	11.0t
Low forecast	9.81t	10.8t	11.2t	11.5t
High forecast	9.81t	9.81t	9.81t	9.81t

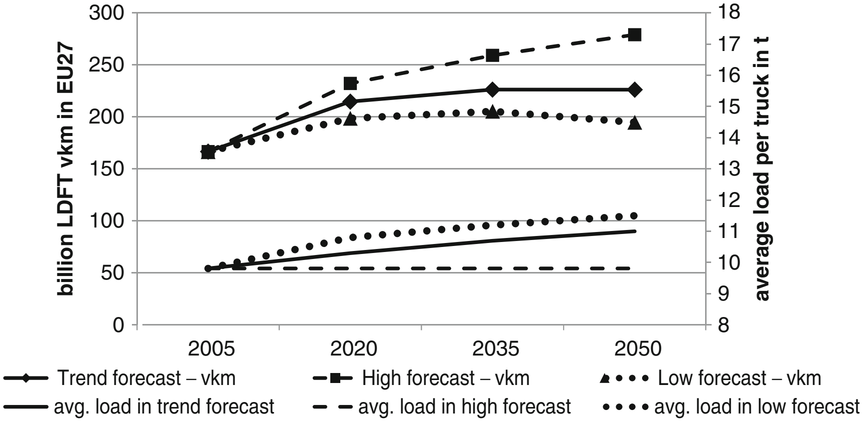

Fig. 6.3 Projection of vehicle km (LDFT)

By combining transport demand, modal split and load factors vehicle km can be projected (Fig. 6.3).

The additional parameters that apply for the four primary criteria are mentioned in the "main assumptions" in its respective section.

6.2 GHG Emission Forecast

Climate change is probably the most urgent environmental problem to be mitigated. Even though long-distance freight transport (LDFT) is a minor source of the total anthropogenic GHG emissions, it is important to reduce the emissions wherever it is feasible. We developed forecasts (trend, low, high) to see what the potential development of GHG emissions in LDFT is by 2050.

Indicator

The indicator used for measuring GHG emissions is

> Total CO_2 equivalents (in tonnes) that are caused by long-distance freight transport by road, rail, and inland waterways within the EU27 (including upstream).

Methodology and Limitations

An analytical framework for assessing forecasts of LDFT GHG emissions and energy consumption (indicated as fossil fuel share). The emission assessment method used is

not a simulation model, but an analytical framework, which depends on other data sources for the technological and economical forecasts. Since there is no feedback between the model elements, possible rebound effects (e.g. increased freight demand caused by improvements in fuel efficiency) have not been taken into account.

Because of the complexity of the interactions between individual trends, a mechanistic modeling approach was chosen. A simple cause-effect model was developed to link the emissions to demand through efficiencies. GHG emissions (as CO_2 equivalents) of the freight transport sector were analyzed through eight parameters:

- emissions caused by the production and use of fuels,
- fuel shares,
- engine fuel efficiencies,
- vehicle energy requirements,
- logistic efficiency,
- vehicle fleet composition,
- modal split, and
- freight volume.

The interactions between these factors were modeled with linear algebra (matrices). The same model was used to analyze the indicator of fossil fuel dependency. The method and data used is presented in detail in Mattila and Antikainen (2009).

GHG emissions are calculated based on life cycle thinking (taking the upstream emissions from fuel and electricity production into account). However, the emissions from the infrastructure (e.g. construction of new road and railway network) and transport equipment and the emissions caused by land use change were excluded. Three electricity backcasts were used to capture the possible variation in future emissions of electric trains.

6.2.1 Trend Forecast

Main Assumptions

The main additional assumptions in the trend forecast include

- promotion of biofuels continues as planned,
- non-conventional fossil fuels, such as diesels from heavy oil and oil tar sand, become more common, reaching a share of 30% of world oil production in 2050,
- carbon capture and storage (CCS) is introduced around 2035 and after that becoming slowly more common, and
- electricity production backcast as presented by IEA 2008 (middle policy backcast with medium investments in renewable energy, nuclear power, and CCS aiming in the stabilization of 550 ppm CO_2 in the atmosphere).

Road is the main emission source, even though there is expected to be an emission reduction of about 35% between the years 2005 and 2050. The emissions are

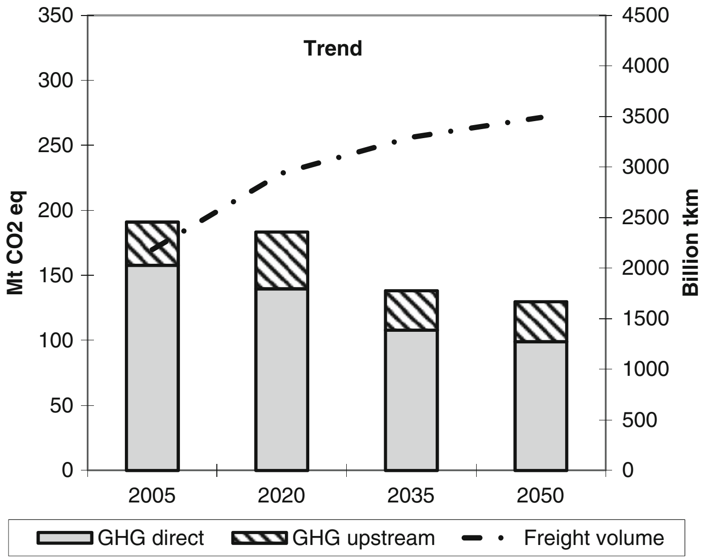

Fig. 6.4 Trend forecast for GHG emissions

dominated by direct emissions, although the relative importance of the upstream emissions increases throughout the study period.

Railways play a constantly increasing role in the trend forecast. In 2005, the share of rail is about 5% of the total emissions, but in 2050 it is expected to be already about 10% with a growing role of upstream emissions from electricity production.

Inland waterways are of minor importance in the GHG emissions of LDFT in the next decades.

Total emissions of LDFT are expected to be reduced by about 30% between the years 2005 and 2050. The reduction is conditional on moderate improvements in engine efficiency, aerodynamics, and rolling resistance of heavy trucks (Fig. 6.4)

6.2.2 Forecast—Lower than Trend

Main Assumptions

The main additional assumptions in the low forecast include

- A strong promotion of biofuels,
- non-conventional fossil fuels play a minor role,
- CCS in wide use already in 2035 and strongly expanding until 2050,
- electricity backcast the lowest plausible (Energy [R]evolution: Greenpeace and EREC 2008) with a very strong investment in renewable energy and a shift away from nuclear and coal power.

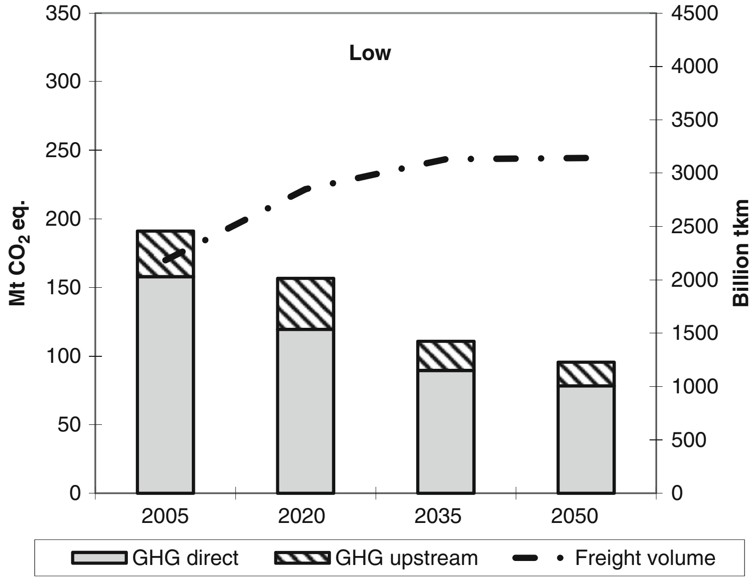

Fig. 6.5 Forecast for GHG emissions—lower than trend

Road is the main source of the emissions also in this forecast, but the emissions are reduced even more than in the trend (by 50% between 2005 and 2050).

Even though the freight volume of rail increases, the emissions are expected to decrease due to assumption that more and more electricity is produced from renewable sources.

Inland waterway is of minor importance in the GHG emissions of LDFT in the next decades.

Total emissions of LDFT are expected to be reduced by 50% between the years 2005 and 2050 in the low forecast. The reduction is conditional on the energy efficiencies, aerodynamics, rolling resistance, and average load factors. The relative importance of the upstream emissions increases throughout the study period for all three modes (Fig. 6.5).

6.2.3 Forecast—Higher than Trend

Main Assumptions

The main additional assumptions in the high forecast include

- relatively low use of biofuels,
- non-conventional fuels are the common source of fossil fuels, reaching a share of 70% in 2050,

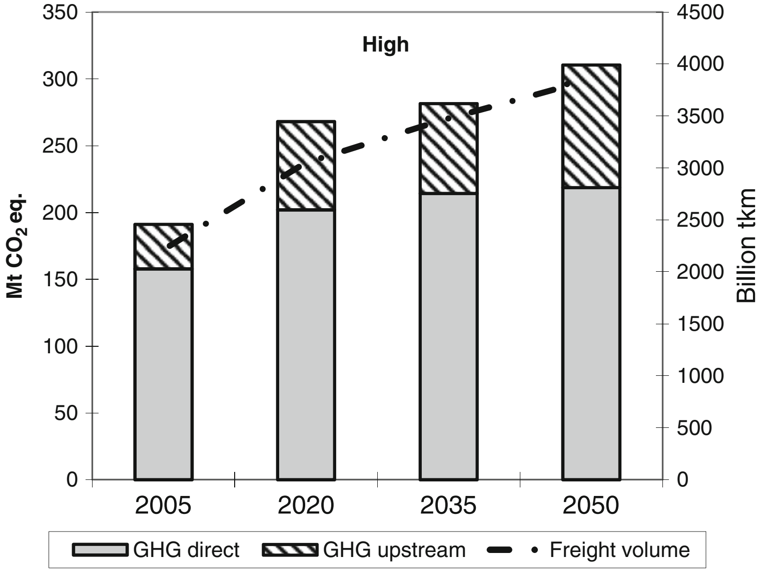

Fig. 6.6 Forecast for GHG emissions—higher than trend

- CCS is not introduced at all,
- electricity production backcast as presented by IEA 2008 (business-as-usual backcast with relatively high share of fossil fuels coal and natural gas).

Road is the main source of emissions also in the high forecast, and they are expected to increase by about 60% between 2005 and 2050.

The emissions from railways are more than double in the high forecast, because it is assumed that the electricity production continues to be highly dependent on fossil fuel sources.

IWW is of minor importance in the GHG emissions of LDFT in the next decades also in this forecast.

Total emissions of LDFT are expected to grow by more than 60% between the years 2005 and 2050 in the high forecast.

The main reasons for the increase are the growing freight volume and increased emissions from refining non-conventional fuels (Fig. 6.6).

6.3 Fossil Fuel Share

Reduction in the share of fossil fuels and thus the dependency on fossil fuels is one of the primary goals in EU. Currently, freight transport has a very high share of fossil fuels and is largely dependent on fossil fuels such as conventional diesel. We analyzed how different forecasts change the fossil fuel and total energy consumption in the freight transport, and used this information to calculate the indicator for measuring fossil fuel share.

Indicator

The indicator used for measuring fossil fuel share is

> Fossil fuel energy input (primary energy) for long-distance freight transport by road, rail, and inland waterways within the EU27 divided by total energy input (primary energy) for long-distance freight transport by road, rail, and inland waterways within the EU27.

Methodology and Limitations

The basis of methodology used is the same as in the analysis of GHG emissions. This means that fossil fuel and total energy consumption are calculated based on life cycle thinking taking the upstream energy consumption into account.

By fossil fuel energy, we mean the sum of fossil primary energy sources (natural gas, coal, petroleum, and peat) consumed in providing the transportation fuel necessary. For fossil traffic fuels, this includes both the energy consumed in refining and the energy embodied in the fuel itself. For electricity this includes the fossil energy sources consumed in electricity production and in obtaining the fuels for electricity production.

By total energy, we mean the sum of all primary energy consumed, including fossil, renewable, and nuclear.

The indicator selected has its own limitations, and it only shows the ratio of the two energy demand parameters. The disadvantage of the indicator is that it can decrease even though the fossil and total energy demand increase, therefore not revealing true reduction in the fossil fuel share. Therefore the fossil fuel and total energy consumption are presented also as absolute figures.

6.3.1 Trend Forecast

Main Assumptions

The main assumptions are the same as in the trend GHG forecast.

Road: In road transport, fossil fuel share is expected to be reduced from 96% to 70%. Contrary to CO_2 emissions, engine efficiencies will not affect this figure. The decrease is mainly caused by a 20% share of biofuels which consume large amounts of non-fossil energy.

Rail: In railways, electrification and increased use of renewable energy in electricity production will decrease the fossil fuel share slightly.

IWW: In inland waterways, no significant changes are expected.

Total: The indicator on fossil fuel share decreases from 94% to about 70% between 2005 and 2050. The demand of fossil energy and total energy are also decreased due to increases in fuel efficiency (Fig. 6.7).

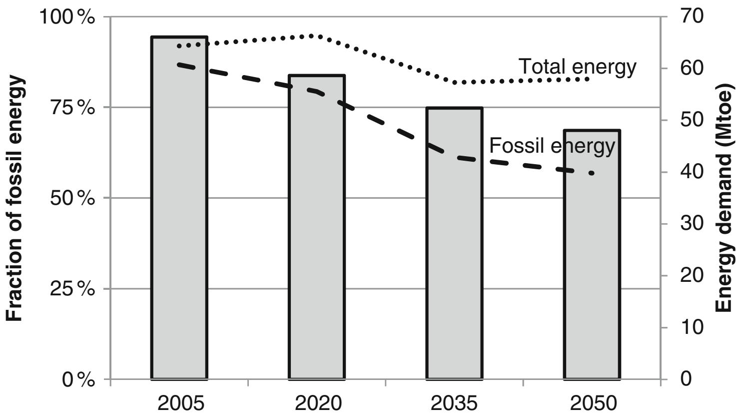

Fig. 6.7 Trend forecast for fossil fuel share

6.3.2 Forecast—Lower than Trend

Main Assumptions

The main assumptions are the same as in the low GHG forecast.

Road: In road transport, the fossil fuel share is reduced from 96% to 60%. This is caused by large increases in the adoption of biofuels.

Rail: In railways, a relative large reduction in the fossil fuel share is expected due to the assumed significant increase in the share of renewables in the electricity production.

IWW: In inland waterways, no significant changes are expected.

Total: The indicator on fossil fuel share decreases from 94% to about 60% between 2005 and 2050. The demand of fossil energy and total energy are also decreased due to improvements in fuel efficiency (Fig. 6.8).

6.3.3 Forecast—Higher than Trend

Main Assumptions

The main assumptions are the same as in the high GHG forecast.

Road: In road transport, the fossil fuel share is reduced from 96% to 70%. However, the demand of both fossil energy and total energy increase (fossil by about 40% between 2005 and 2050, and total almost 100% during the same period of time).

Rail: Fossil fuel share increases because electricity production continues to be highly dependent on fossils.

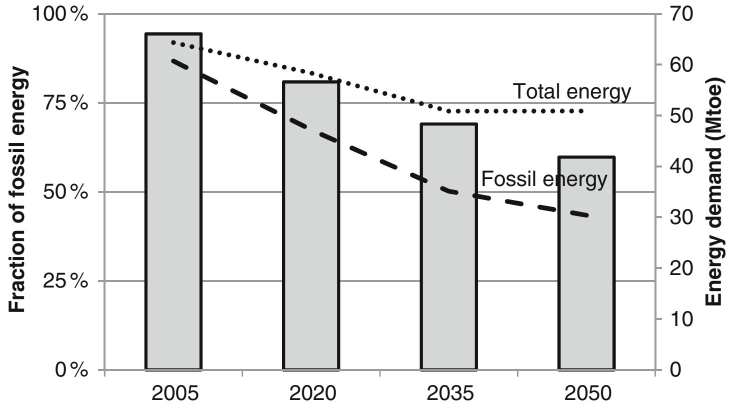

Fig. 6.8 Forecast for fossil fuel share—lower than trend

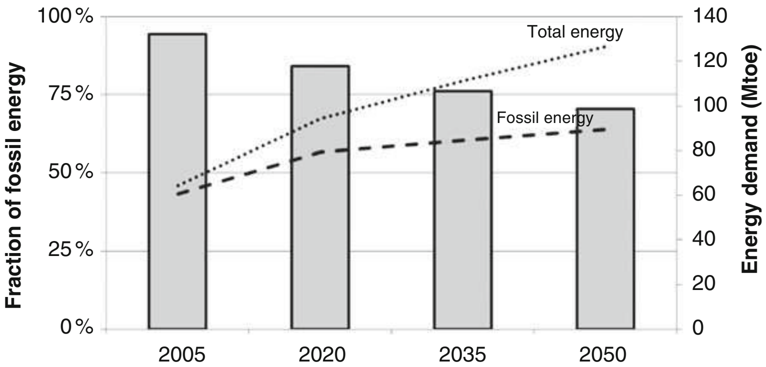

Fig. 6.9 Forecast for fossil fuel share—higher than trend

IWW: In inland waterways, no significant changes are expected.

Total: The indicator on fossil fuel share decreases constantly from 94% to 70% throughout the study period, despite the fact that demand of both fossil energy and total energy increase (fossil by 50% between 2005 and 2050, total almost by 100%). The increase in total energy consumption is driven by a combination of increased biofuel use, non-conventional oil refining, and lack of improvements in energy efficiency (Fig. 6.9).

6.4 Congestion

Companies and logistics networks are strongly affected by congestion as it leads to delays and increased uncertainty which harms delivery reliability. Therefore, congestion increases cost due to higher operating cost (e.g. additional wages and equipment) and more safety inventory has to be carried in order to cope with the uncertainty.

Furthermore, congestion weakens the customer service especially when just-in-time delivery is desired.

Indicator

The indicator chosen for congestion is

> Delay time measured as the difference between travel time in a loaded network and an unloaded network multiplied with the number of trucks affected for an average day.

Methodology and Limitations

In order to assess congestion, it is indispensable to model the demand within a network. For the mode road this was done using the multimodal model of TRANS-TOOLS. As future network developments until 2050 are highly political, uncertain and dependant on bottlenecks, the TEN network was assumed to be completed, yet any other adaptation was excluded. This results in a disproportional development of congestion values towards 2050, because of the non-linear nature of congestion.

Modeling in a road-based environment is relatively simple in comparison to railway modeling due to the unique nature of railway systems that require a large amount of details in order to result in comparable numbers. There are detailed models, but they are closed to the public. Within the project team, there was no modeling tool for calculating transport demand effects on the rail network available. Therefore modeling has only been done for the road network using TRANS-TOOLS.

Statements on congestion in rail and inland waterways were therefore given from experts in a qualitative manner.

Modeling is very time consuming and requires detailed input parameters in order to calculate different results. It was therefore refrained from calculating low and high forecasts using TRANS-TOOLS.

All of the following figures refer to the EU27. The individual countries may differ.

6.4.1 Trend Forecast

Main Assumptions

In addition to the assumptions stated above, the following have been made.

- No change in infrastructure between 2020 and 2050.

  Road: Congestion as an aggregated figure for all EU27 countries increases by and large linearly throughout the entire projection period. It starts with 0.65 million

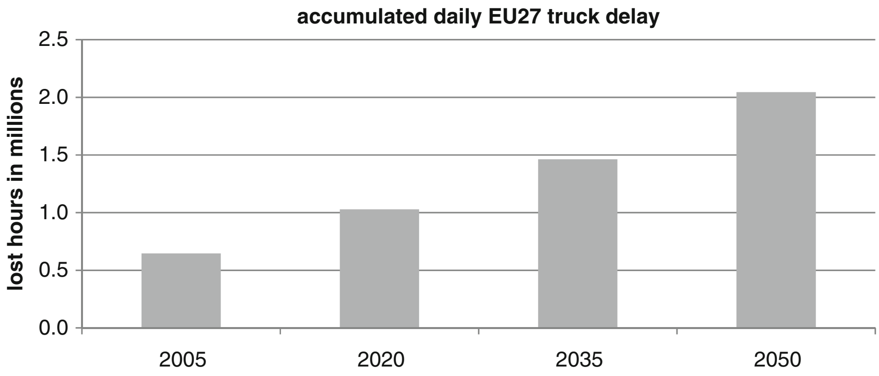

Fig. 6.10 Accumulated daily EU27 truck delay

lost hours in 2005, to 1.03 million in 2020, 1.46 million in 2035, and 2.05 million in 2050. It must be added that by 2050 the model becomes very uncertain. On different day categories and regionally these figures vary strongly (Fig. 6.10).

Rail: Growth rates for railway freight transport are projected to increase faster than road transport in the trend forecast in tkm. As tkm grow by more than 90% until 2050, capacity problems will inevitably increase. This is especially the case:

- At the port/landside interface (Port Hinterland),
- at railway hubs,
- in saturated parts of the network,
- in parts of networks when passenger trains are given the priority, and
- at border crossings.

According to the punctuality report of UIRR (2007) in combined transport on major European corridors, 37% of all the concerned intermodal trains are more than 1 hour delayed; 21% are delayed by more than 6 hours. The VDV (2009) presented a list of almost 400 locations for Germany where investment in rail infrastructure is necessary; many of them affecting freight trains.

Especially main trans-European corridors are already at or beyond capacity limits and require investment in order to keep up with the demand by passengers and freight. Congestion rises disproportionally by the degree of utilized capacity, because it is an exponential function.

IWW: With inland waterways, congestion is very limited despite projected increases in demand. The European Freight and Logistics Forum (1998, p. 13) stated that "the operators as well as the terminal/port operators indicate having sufficient spare capacities available to absorb additional traffic." As tkm increased in the EU15 since 1998 by less than 10%, this statement remains by and large true. There are cases where some of the watergates may not be suited to accommodate larger vessels, or additional or wider locks are necessary to keep the

possible delay at an acceptable level, despite the high demand. Yet the general outlook can be considered as good, since major rivers can accommodate significantly more vessels than today.

6.5 Fatalities from Road Accidents Involving HGV

The transport system causes a high number of road fatalities within the EU27. Between 1990 and 2006 in what is today the territory of the EU27, approximately 1 million inhabitants were killed on Europe's roads, thereof 13% are assignable to HGV. By assignable we mean that a HGV is involved in the accident. This explicitly excludes the question on who is legally liable to have caused the accident.

A strongly increasing freight performance in the next decades has the potential to offset the targets set by the EU's white paper on transport in 2001.

Indicator

The indicator used to measure the impact of road fatalities is

> The number of road fatalities within the EU27 attributable to HGV.

The indicator was chosen, because alternatives in terms of injuries or monetary values are difficult to estimate, since there is no comprehensive database for the EU27 and underreporting is likely to be higher than with fatalities from road accidents. Furthermore it matches common targets set by the EU.

Rail and IWW have low fatality numbers and on a European scale data cannot be separated between passenger transport and long-distance freight transport. Due to a lack of sufficient data assignable to freight transport, it was not possible to evaluate the number of fatalities for rail and IWW.

Methodology and Limitations

Based on data available within the CARE[1] database respectively from Eurostat, CE Delft (2009, p. 30) states that roughly 13% of all road fatalities are attributable to HGV, which is derived from the CARE database between 1990 and 2005. This empirical finding was used to calculate a road fatality rate per billion vehicle km. In the forecast influencing parameters such as public awareness campaigns, ITS, and collision avoidance systems have a varying impact on the generally declining fatality rate.

1 **C**ommunity database on **A**ccidents on the **R**oads in **E**urope.

6.5.1 Trend Forecast

Main Assumptions

- By 2035 (but not before) and 2050, especially collision avoidance systems are expected to be widespread and thus contribute toward a reduction of fatalities drastically.

Road: In the trend forecast the number of fatalities is at first projected to rise due to very fast growing vehicle km and a still pending wide implementation of collision avoidance systems.

By 2035 and 2050, especially collision avoidance systems are expected to be widespread and thus contribute toward a reduction of fatalities drastically. At the same time the rapid development of the vehicle km will flatten. The average load is increasing, which almost offsets the growth in tkm after 2020 (Fig. 6.11).

6.5.2 Forecast—Lower than Trend

Main Assumptions

- Early and wide implementation of technological developments like collision avoidance systems and ITS warning systems.

Road: Unlike the trend and high forecast, the number of fatalities is expected to fall continuously. This is mainly due to an early and wide implementation of technological developments like collision avoidance systems and ITS warning systems.

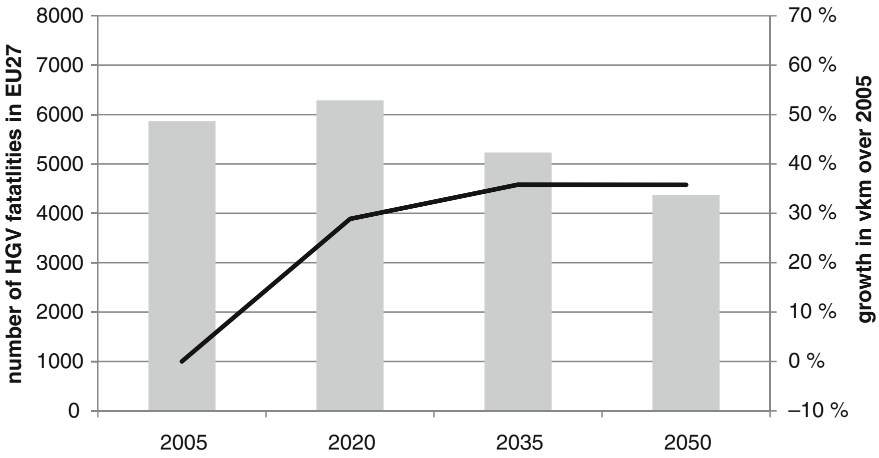

Fig. 6.11 Trend forecast for fatal accidents

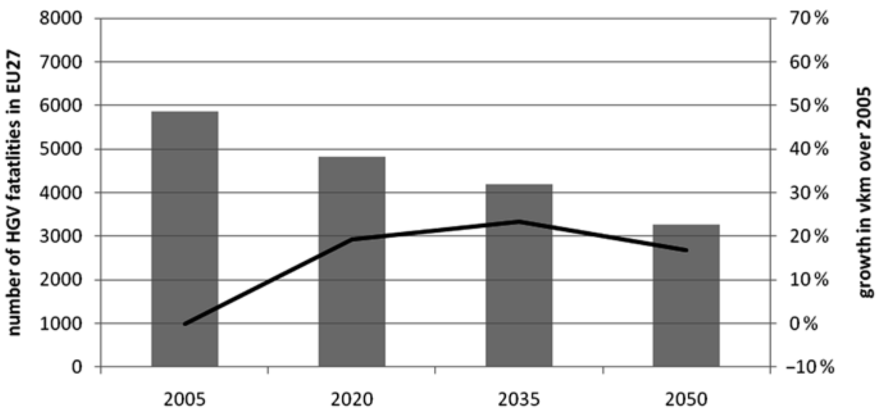

Fig. 6.12 Forecast for fatal accidents—lower than trend

Additionally the number of tkm and vehicle km, respectively, is expected to be lower. The main contributor to lower vehicle km is an increased average load.

The market penetration of ITS and collision avoidance systems by 2050 is higher than with the two other forecasts. Furthermore the impact of public awareness campaigns is assumed to be higher (Fig. 6.12).

6.5.3 Forecast—Higher than Trend

Main Assumptions

- Late dissemination of ITS and collision avoidance systems as well as a low impact of public awareness campaigns

Road: The high forecast combines a high growth rate in tkm with a constant average load, which results in intensely increasing vehicle km throughout the entire period. The late dissemination of ITS and collision avoidance systems as well as a low impact of public awareness campaigns result in a higher number of fatalities that are attributable to HGV than today across all three forecast horizons (Fig. 6.13).

6.6 Conclusions

The three different forecasts and their quantification in terms of GHG emissions, fossil fuel share, congestion, and accidents is an intermediate step that indicates where we are heading for if the most fundamental parameters remain as they are today. There

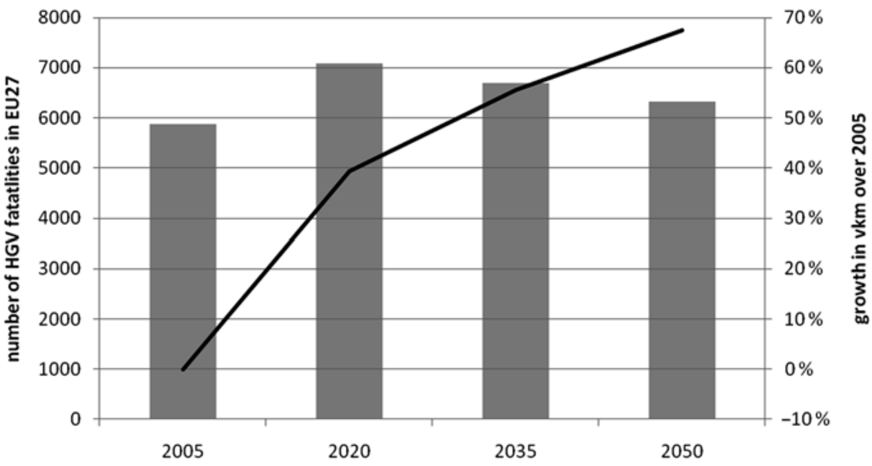

Fig. 6.13 Forecast for fatal accidents—higher than trend

are technological chances to mitigate toward the commonly agreed societal targets in the lower than trend forecast; yet this forecast already includes some rather optimistic assumptions. The contrasting forecast higher than trend can be considered as a nightmare to our societies.

In the pending steps of FREIGHTVISION the reduction possibilities will be evaluated and compared to the improvement. The forecasts are therefore quantification references for the individual reduction visions that are to be developed in the upcoming phases.

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7 Vision

David Bonilla and Nihan Akyelken

Abstract The vision is defined as a set of ethically and socially desirable goals for the four main sustainability criteria in focus – GHG (Greenhouse Gas) emissions, share of fossil fuels, congestion and road fatalities. The targets set by the vision are normative targets, that is, they reflect socially desirable goals and values and reflect in some cases EU policy targets. The vision is to reduce GHG emissions by 80% and to decrease fossil fuel dependency to 40% by 2050. Regarding risk factors, the vision sets a reduction of 80% in road fatalities, and 40% reduction in congestion levels by 2050.

7.1 Introduction

The vision describes where EU freight policy and stakeholders (of EU freight sectors) want to be, before deciding how to do so, by 2050. Policy makers should first set the vision for desired targets. The vision is defined as a set of targets for the four main sustainability criteria in focus – GHG (Greenhouse Gas) emissions, share of fossil fuels, congestion and road fatalities. A set of targets for 2050 have been generated for the four primary criteria that shape the vision. The targets given are normative targets, that is, they reflect socially desirable/acceptable goals and values and reflect, in some cases, EU policy targets. The goals are quantitative and are defined using the indicators described in the forecast chapters (see preceding pages), and it is important to note that they are not predictions, but they involve an idea of the magnitude of change required.

For developing these quantitative goals, two views are taken. The first view proposes ethically and politically desirable goals for LDFT until 2020, 2035 and 2050 years; the second one proposes feasible goals to the year 2050. The feasibility of the goals pursued has been established in the back casting exercise (see below).

It should be kept in mind that social and political goals can only be assumed for sustainability in the mid-term and the long-term periods. These policy goals have to be complemented with additional assumptions for short-term sustainability.

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The vision is complemented with the main policy targets described in:

- 20-20-20 energy/climate goals proposed by the European Commission (EC White Paper, 2001);
- Stern report (Stern, 2007, 2009);
- Intergovernmental Panel of Climate Change Report (IPCC 4th Assessment Report);
- Kyoto Protocol targets on GHG and ongoing negotiations on GHG mitigation;
- 2001 EC White Paper and mid-term review of the EC White Paper.

To complement the goals mentioned in these documents, the following additional assumptions have been taken:

- Long-distance freight transport (LDFT) is not favored over other forms of transport (e.g. to passenger transport);
- Linear, and downward sloping, trends track the vision's goals;
- Low-forecast path is considered as a possibility.

For each criterion, described below, policy goals and assumptions are considered when developing the vision.

7.2 GHG Emission Reduction (Criterion)

GHG mitigation is a global challenge and thus European policy, and the vision set out here, have to be considered in the context of global decision-making processes. The vision accounts for the consequences of a global perspective for European policy-making.

GHG Emissions – Global Perspective

The world's climate scientists of the IPCC, (IPCC, 2007, Summary of Policy Makers) argue that, to limit temperature increases to not more than 2°C, a 50–% decrease of global CO_2 emissions is needed in the period between 2000 and 2050.

Global GHG emissions (in CO_2-eq.) stand at 6.3 Gt CO_2 (IPCC, 2007; Kahn et al., 2007) for the whole of transport. The lion's share of CO_2 emissions of global transport activity is taken by passenger vehicles and freight vehicles accounting for three quarters of global transport. Trucks account for at least 25% of global CO_2 emissions of transport. In contrast to trucks the shipping sector (short sea and overseas) accounts for 6% of global CO_2 emissions.

The United States is the largest single source of world transport CO_2 emissions (all modes of transport) with 1,785 Mt CO_2 or about a third of global CO_2 emitted by world transport. US truck freight is responsible for 388 Mt CO_2 (US, EPA, 2010), while EU truck emissions stand at 190 Mt CO_2 (EU-27), a level significantly below that of US truck freight LDFT. Nonetheless EU-27 freight transport performance is less dominated by the rail mode (19% of total EU freight, excluding air freight) than the performance

of US freight (with a share of rail of 33% of total US freight). On this basis EU freight is less energy efficient than US freight transport.

Emissions – European Perspective

The EU Commission recently announced that "In order to limit the global average temperature increase to not more than 2°C above pre-industrial levels, developed countries as a group should reduce their emissions to 30% below 1990 levels by 2020". (EU Commission, 28 of January, 2009). The EU unilateral target is 20% reduction in GHG emissions by 2020 with 1990 as the baseline. The EU has announced two targets to 2020 with the strictest target in case an international agreement is reached (targeting a reduction of 30% of GHG emissions by 2020).

It is difficult to measure energy use and CO_2 emissions of freight transport, but CO_2 emissions in 2005 (for LDFT) stand at roughly 190 (Mt CO_2) if we account for indirect and direct CO_2 emissions. LDFT accounts for roughly 50% of total CO_2 emitted by the entire transport sector in 2005 of EU27.

Vision for LDFT

In the development of the vision the following policy documents have been considered in the formulation of our assumptions:

- EU 20-20-20 target for 2020 (EU White Paper, 2001);
- CO_2 targets (IPCC 4th Assessment Report) for 2050;
- The Stern Report (Stern, 2007) argues that early action on CO_2 mitigation is cost effective to contain the cumulative increase in GHG emissions. Any delay in CO_2 reduction is costly and dangerous (Stern, 2007).

Further assumptions include that transport will be expected to reduce levels of CO_2 (in % terms) just as the rest of the economy-wide GHG reduction targets: a minus 80% target is applicable to freight transport; both passenger and freight transport have to achieve equal declines (in % reduction targets).

Table 7.1 describes the targets for CO_2 at each target year. These reductions are compared to 2005.

Table 7.1 GHG emissions – vision

	2020	2035	2050
Reduction of GHG emissions	−40%	−70%	−80%

7.3 Fossil Fuel Share (Criterion)

The strong dependence on fossil-fuel use (reflected in the high share of fossil fuels of freight energy use (EU27 LDFT)) is currently on top of the European political agenda due to high oil prices in 2008 and due to both: dependency on imported oil and gas and to the conflicts related to gas delivery between Russia and the Ukraine. Therefore the large role of fossil fuels in EU freight energy use cannot be seen with the same optic as the issue of GHG mitigation as two additional uncertainties should be added: geopolitics and fluctuating prices of oil and gas. Since transport has a high share of fossil fuels, freight transport is currently vulnerable and political action and preventive measures are necessary. These issues enhance the importance of developing a vision, for EU wide freight transport, for reducing the dependence on fossil fuels of freight transport in the EU-27 Member States.

Fossil Fuels – Global Perspective

Ninety five percent of world transport energy is fossil fuel based (diesel and gasoline) and approximately half of global energy use (transport only) comes from freight transport. World freight is dominated by the shipping mode (in physical terms), but the largest chunk of transport energy use comes from truck freight. A policy challenge, therefore, is to reduce fossil fuel use of mainly trucks, without reducing global trade.

The LDFT truck energy share (16% EU27; Eurostat, 2009; SYKE, 2009) of overall energy use of transport (EU only) is similar to the US equivalent share of 17% (Transportation Energy Data Book, 2007).

Fossil Fuels – European Perspective

Another challenge is the prospect of peak oil and higher oil prices in the context of growing demand for fossil fuels. Rapidly growing demand has led to fossil fuel import dependency and has made EU policy-makers aware of the need to reduce its vulnerability. Most EU oil supply is sourced from two regions: the Middle-East and Russia and future growth in demand for energy to power freight movements also imposes pressure on EU-wide energy dependence.

LDFT accounts for one-half of transport energy by the entire transport sector in 2005 of EU27 (ETAG, 2009). Current fossil fuel dependence is 94% of total LDFT energy use, since the main mode (truck) relies on diesel fuel. To reduce that dependence, the EU adopted the Energy Charter Declaration in 1991 to diversify its sources of energy supply. This was followed by the Energy Charter Treaty to incentivise energy cooperation. To this date, 51 nations and the EU have signed the agreement.

The EU agreed in the 20-20-20 target formula to increase the share of renewables in its overall energy mix to 20%, including a 10% biofuel target for transport by 2020.

Vision for LDFT

In developing the vision the following has been considered:

- EU 20-20-20 target for 2020; 30% GHG reduction target, from 1990 level, if conditions permit;
- It is assumed that transport will be expected to reach a similar share of renewables as the rest of the economy;
- It is assumed that the share of renewable energy will be the same across the board for freight transport and passenger transport;
- It is assumed that the EU will also try to decrease its fossil fuel share after 2020. For this timeframe (2020–2050) a linear decrease in the share of fossil fuel is assumed.

Table 7.2 describes the targets for fossil fuel share at each target year.

Table 7.2 Fossil fuel share – vision

	2020	2035	2050
Reduction of fossil fuel share	80%	60%	40%

7.4 Congestion (Criterion)

Congestion is high on the EU agenda, since it is a serious threat to competitiveness by (1) increasing costs for the EU27 freight industry and (2) by increasing CO_2 and non-CO_2 emissions. EU studies on congestion (percentage of congestion costs of GDP) show the following figures: for 2000, the 2001 White Paper on transport reports a value of 0.5% of EU GDP, the 2008 Green Transport Package reports the 2008 level as 1.1% of EU GDP and the 2001 White Paper predicts a value of 1.5% of EU GDP, which represents a 142% increase in costs. Congestion costs are expected to be as high as 1.5% of GDP by 2020 and they are likely to increase substantially in the years to come as growth is set to continue. These figures are significantly beyond an acceptable level and cover overall transport.

In addition mitigating transport disruptions, caused by congestion, is of crucial importance for LDFT as it has a significant impact on delivery time and reliability. In contrast to the case of environmental externalities, congestion costs can be considered to be internal to the transport sector as a whole. According to Eurostat, 6% is added to the EU road transport fuel bill by traffic congestion.

Levels of truck-km driven for HGVs have increased by around 15% between 1995 and 2005, and it is expected to increase by 20% by 2020 (European Transport Report Ausgabe 2007/2008). This translates into LDFT as an increase of 27% from 2005 to 2020, and the rate is expected to decrease to 9% from 2020 to 2035 and to 3% from 2035 to 2050 based on the projections carried out by Transver on the Progtrans (2007) and Eurostat projections with an assumption of constant load factor.

In the rail network, congestion will continue leading to possibly longer rail freight journeys due to market specialization, and due to this, rail freight will be more sensitive to regional bottlenecks, but this helps to reduce truck congestion.

In IWW no major congestion occurs because of free-capacity. However congestion at the ports when handling containers will be a bottleneck in future. Such congestion has indirect effects on inland waterway traffic, truck freight and on rail freight modes, especially in regional hubs.

Vision for LDFT

To our knowledge, there is no concrete quantitative target (EU27), by the EU Commission, for reducing congestion by the year 2050. The only EU target relevant for congestion levels is to slow the increase of road haulage transport to 38% until 2010, instead of 50% as indicated in the 2001 White Paper.

The action scenario developed by the TRANS-TOOLS model shows that it is not feasible to go beyond the 26% reduction in congestion by 2035. Given its significance, we propose a reduction of 26% by 2035. According to this, the vision for 2020 and 2050 proposes a 13% and a 40% reduction (base year 2005), respectively.

Table 7.3 describes the targets for congestion reduction at each target year. These reductions are compared to 2005.

Table 7.3 Reduction of congestion – vision

	2020	2035	2050
Reduction of congestion	−13%	−25%	−40%

7.5 Road Fatalities (Criterion)

The costs of road fatalities are not limited to human lives: accounting for 2% of GDP, its economic costs deteriorates everyone's lives (as of 2001). The EU target published in the 2001 White Paper was to reduce road deaths by 50% until 2010. The 2006 mid-term review of the White Paper reported that the road fatalities have declined by more than 17% since 2000.

The current figure and this figure in 2005 show that the target of reducing road fatalities by 50% in 2010 is not likely to be met. Current conditions show that the number of road fatalities is likely to stand at 32,500 in 2010, not at around 28,000 as targeted. The number of road fatalities will have been reduced by only 30% since 2001. Moreover, it is important to note that the EU target covers EU-15 only.

Looking at the countries separately, we see both similarities and differences with the EU-average:

- The share of road fatalities involving trucks is almost the same the EU-average (13%) in France.
- The Dutch Government put a target of 580 road fatalities overall by 2020.
- Sweden and the UK are the leader in road safety. The Vision Zero approach employed by Sweden requires Sweden to have 0 fatalities by 2020. Having made significant developments in road safety, UK has also been considering the Vision Zero approach. While Sweden and the UK have already achieved major reductions in road fatalities since 1990, further reductions have become progressively difficult to achieve. However, adopting ambitious targets makes it more feasible to achieve much higher reductions even if the target is not met.

Inventiveness in reducing the frequency of truck accidents should be given a high priority because trucks carry a higher risk as they are related to changes in logistics, which in turn, affect hauling distance and truck-related road fatalities. The other modes of long-distance freight are relatively safe.

Moreover, the continuation of the spatial division of production is a key driver for accidents. It increases road fatalities, since it is closely related to logistics trends as the changes in the number of freight trips are highly relevant for the number of road fatalities involving freight vehicles.

Vision for LDFT

The EU will not have managed to reach the 50% reduction target by 2010, since the on-road fleet (freight vehicles) will increase considerably by 2050. Moreover, freight transport will have become more diversified and less reliant on the road freight mode. Considering these assumptions, and assuming further EU enlargement,

- The reduction of road fatalities should be around 40% per 15 years, which roughly corresponds to the current trend, i.e. the road fatalities from LDFT should not exceed 1,267 by 2050. The 13% share of road fatalities attributed to HGVs is considered for this target.
- In order to reach this target, the number of road fatalities should follow the same decreasing rate, since the number of inhabitants is not likely to change significantly in the next 40 years.

Table 7.4 describes the targets for reduction in road fatalities at each target year. These reductions are compared to 2005.

Table 7.4 Number of road fatalities with involvement of HGV – vision

	2020	2035	2050
Road fatalities (compared to 2005)[1]	−40%	−65%	−80%
Road fatalities in absolute numbers	3,500	2,100	1,300

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8 Scenario

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Abstract The goal of FREIGHTVISION's scenario building was to find one realistic Scenario, how the future could develop. The methodology for developing the FREIGHTVISION Scenario was Backcasting based on the same models which were used for Forecasts. In this chapter the methodology and the results of the Scenario development are presented.

8.1 Introduction

The goal of FREIGHTVISION's scenario building was to find one realistic scenario, how the future could develop. The methodology for developing the FREIGHTVISION scenario was backcasting based on the same models which were used for forecasts. In this chapter the methodology and the results of the scenario development are presented.

The purpose of this FREIGHTVISION scenario exercise was twofold. On the one hand, it provides a tool to check if the vision defined is realistic or unrealistic. This was very important for the project as the vision proposed should be achievable and no utopia. On the other hand, it should show a way how the vision can be reached and thus was the basis for the action plan.

The concept of the scenario development was to develop only one "realistic" scenario. In other FORESIGHT projects often a few different scenarios are developed. Each scenario is based on a specific paradigm and the whole scenario is derived from this paradigm. Examples for such paradigms are "impulse/strong activity", "laissez-faire", and "recession". The advantage of these scenarios is that they are consistent and intellectually interesting, but can be on the other hand exaggerated and thus considered as being unrealistic and therefore of limited relevance for policy making.

In FREIGHTVISION a different approach was taken: the goal was to find one realistic scenario, how the future could develop. The advantage of this procedure is that such an approach is much more challenging both for stakeholders and policy makers as they cannot argue in the discussion with alternatives. Within the project development the FREIGHTVISION scenario was very much challenged by some of the stakeholders searching for arguments why this scenario is wrong.

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8.2 Backcasting – Methodology

The methodology for developing the FREIGHTVISION scenario was backcasting. The scenario was developed using the same models which were used for forecasts, but they were used differently.

The forecasts analysis started from 2005 looking into the future. A "BAU-development" of the transport system's key characteristics until 2050 was assumed. Based on that, the development of the four sustainability criteria until 2050 was calculated using the SYKE model and TRANS-TOOLS.

In contrast the backcast approach was the following:

- The analysis started in 2050 going back to present.
- A certain development of the sustainability criteria until 2050 was assumed. These numbers were taken from the vision.
- The TRANS-TOOLS and SYKE models were used to find a certain set of figures for the "key characteristics," where the development of the sustainability criteria is met.[1]
- For the assumed developments of the key characteristics, a plausibility check was done, considering the external factors.

Maybe an example clarifies the methodology: In the vision it was defined that the target for GHG emission reduction is −80% until 2050. The question addressed in the backcast exercise was the following: How do the key characteristics (modal split, engine efficiency . . .) have to develop until 2050 that according to the SYKE model a reduction of 80% GHG emission will be achieved by then.

Therefore the vision was the starting point, when using the models. The targets defined in the vision were used as the model's output parameters, and the objective was to find developments for the key characteristics which are plausible. Therefore it was the main challenge to push the limits of the key characteristics and to look if there are indications that the key characteristics might develop in this direction, if policy will support it.

After defining the scenario for 2050, in a second step the backcast was extended to 2035 and in a third step to 2020. The result of the whole backcast was

- a consistent and realistic scenario,
- based on models,
- where the vision is reached, and
- the development of the key characteristics is plausible with regard to the key drivers.

1 This approach is also sometimes called 'Reverse Engineering' as the models were used "reverse": The models output parameters (the Sustainability Criteria) were defined in the first step. In the second step the model input parameters (Key Characteristics) had to be adapted until the output parameters were met.

8.2.1 GHG Emissions and Fossil Fuel Share

The backcasts of GHG emission and fossil fuel share was done using the SYKE model. Both backcasts use the same key characteristics. The most important ones are listed below.[2] For each key characteristic

- a definition,
- the number for 2005, and the assumed development until 2020, 2035, and 2050, and
- some arguments about the plausibility of the development are listed.

Transport Performance

Definition: Total transport performance of road, rail, and IWW in billion tkm.

Assumed development (Table 8.1):

Table 8.1 Scenario – development of transport performance

	2005	2020	2035	2050
	2.180 billion tkm	2.840 billion tkm	3.120 billion tkm	3.140 billion tkm
Increase		30%	+43%	+44%

Plausibility argument: This maximum increase is taken from the BAU-low-forecast.

Engine Efficiency

Definition: Efficiency of the combustion engines used in trucks and trains.

Assumed development (Table 8.2):

Table 8. 2 Scenario – development of engine efficiency

	2005	2020	2035	2050
Engine efficiency	42%	51%	59%	61%
Improvement		21%	+40%	+45%

Plausibility argument: In the analysis of the key drivers, a 20% increase of diesel engine efficiency was projected by 2020. The engine efficiency of 60% is close to the highest currently achieved level in diesel power plants and ships, where the heat of exhaust is converted to mechanical power (heat recovery). Truck manufacturers of the 21st Century Truck Consortium (DOE, 2006) have set targets of 55% demonstration in 2012. In effect it is assumed that manufacturing technology will make it possible to fit a power station into a truck by 2050 and to get a 5% improvement in diesel engine within the next 38 years. The assumed efficiency improvements include also improvements due to new fuel types and using hybrid technologies.

2 For information on the other Key Characteristics and references see Appendix.

Vehicle Energy Demand

Definition: Vehicle energy demand of road, rail, and IWW. (MJ needed to move 1 tkm.)

Assumed development (Tables 8.3–8.5):

Table 8.3 Scenario – development of vehicle energy demand road

Road				
	2005	2020	2035	2050
Delivery truck	0.37 MJ	0.30 MJ	0.22 MJ	0.19 MJ
25t Truck	0.25 MJ	0.20 MJ	0.15 MJ	0.13 MJ
40t Truck	0.19 MJ	0.15 MJ	0.11 MJ	0.10 MJ
Improvement		−20%	−40%	−50%

Table 8.4 Scenario – development of vehicle energy demand rail

Rail				
	2005	2020	2035	2050
	0.12 MJ	0.12 MJ	0.11 MJ	0.09 MJ
Improvement			−10%	−20%

Table 8.5 Scenario – development of vehicle energy demand IWW

IWW				
	2005	2020	2035	2050
MJ	0.10 MJ	0.10 MJ	0.09 MJ	0.08 MJ
Improvement			−10%	−20%

Plausibility argument: The improvements in road are based on the targets of the 21st Century Truck Consortium. This could technically be obtained by improving rolling resistance in tires, designing trucks for aerodynamics, improving transmission, and electrifying auxiliary loads. The assumed improvements in rail and IWW are lower due to longer life-cycles and already very high vehicle efficiency.

Low Carbon Electricity

Definition: Upstream emissions in producing electricity (CO_2 equ. in kg/MJ).

Assumed development (Table 8.6):

Plausibility argument: This is based on the assumption that climate change will be mitigated in all sectors. With carbon intensive electricity, mitigation in transport would be useless in mitigation of the climate change (Greenpeace, 2008).

Table 8.6 Scenario – development of low carbon electricity

	2005	2020	2035	2050
	0.123 kg	0.077 kg	0.048 kg	0.015 kg
Improvement		−37%	−61%	−88%

Biofuels

Definition: Upstream emission in producing biofuels (CO_2 equ. in kg/MJ) and the share of biofuels.

Assumed development (Table 8.7 and 8.8):

Table 8.7 Scenario – development of biofuels upstream emissions

Upstream emissions				
	2005	2020	2035	2050
	0.070 kg	0.046 kg	0.012 kg	0.012 kg
Improvement		−35%	−83%	−83%

Table 8.8 Scenario – development of biofuels blending

Blending			
2005	2020	2035	2050
2%	8%	24%	33%

Plausibility argument: Due to replacement of emission intensive vegetable oil esters by 2nd generation lingo-cellulosic biofuels strong emission reduction is expected. Due to lower total energy demand, the absolute demand for biomass is lower than the 10% EU target in 2020. In the scenario the absolute energy provided with biofuels does not significantly increase between 2020 and 2050. The higher percentage rate of biofuels is due to decreasing total energy demand (and thus a higher share of biofuels despite a constant production level).

Efficient Usage of Vehicles

Definition: Road transport efficiency which is not covered in vehicle or engine efficiency. It covers several areas like loading factors, empty runs, driver behaviour, etc.

Assumed development (Table 8.9):

Plausibility argument: There seem to be many improvements possible like logistics (packaging, increased loading factors, despeeding), driver behaviour (lower speed, continuous driving), reduced congestion, platooning, and ITS systems.

Table 8.9 Scenario – development of efficient usage of vehicle

	2005	2020	2035	2050
Improvement		−8%	−30%	−50%

Electric Energy in Road Transport:

Definition: Percentage of electric primary energy input for trucks. (It does not include energy recovery as this is part of engine efficiency.)

Assumed development (Table 8.10):

Table 8.10 Scenario – development of electric energy in road transport

2005	2020	2035	2050
–	0%	10%	25%

Plausibility argument: Currently electric propulsion systems are not considered to be a mid-term option for long-distance road freight transport. However for urban transport, it is assumed that electric propulsion systems will be in use. If this will come true and electric energy will be cheaper than fossil fuels, the project team assumed that electric energy will also be used for shorter inter-urban trips (up to 150 km) and also for the first part of longer distance trips.

Modal Split

Definition: tkm transported in the modes road, rail, and IWW (in billion tkm)

Assumed development (Tables 8.11–8.14):

Table 8.11 Scenario – development of transport performance road

Road				
	2005	2020	2035	2050
	1.635 billion tkm	2.125 billion tkm	2.185 billion tkm	2.045 billion tkm
Increase		30%	33%	25%

Table 8.12 Scenario – development of transport performance rail

Rail				
	2005	2020	2035	2050
	415 billion tkm	540 billion tkm	700 billion tkm	790 billion tkm
Increase		30%	70%	90%

Table 8.13 Scenario – development of transport performance IWW

IWW				
	2005	2020	2035	2050
	135 billion tkm	165 billion tkm	235 billion tkm	315 billion tkm
Increase		20%	170%	230%

Table 8.14 Scenario – development of modal split

Modal split				
	2005	2020	2035	2050
Road	75%	75%	70%	65%
Rail	19%	19%	22.5%	25%
IWW	6%	6%	7.5%	10%

Plausibility argument: This modal shift seems to be possible as longer distances favour rail and IWW, and the USA and some European countries have much higher rail shares. Nevertheless a 25% market share of rail in Europe seems to be very ambitious considering other studies like (FERRMED, 2009).

Truck Weight and Dimension:

Definition: Percentage of tkm transported with larger trucks (40t load).

Assumed development (Table 8.15):

Table 8.15 Scenario – development of truck weight and dimension

	2005	2020	2035	2050
Increase		2%	8%	10%

Plausibility argument: Although it is an economic advantage to use larger trucks, the project team assumes that there is an upper limit of about 10%, as larger trucks can only be used on certain parts of the transport network.

Electrification of Rail:

Definition: Percentage of rail tkm transported with electric engines.

Assumed development (Table 8.16):

Table 8.16 Scenario – development of electrification of rail

	2005	2020	2035	2050
Electric rail	64%	66%	75%	80%
Diesel rail	36%	34%	25%	20%

Results

In Fig. 8.1 the scenario, the vision and the BAU forecasts are shown for GHG emissions.

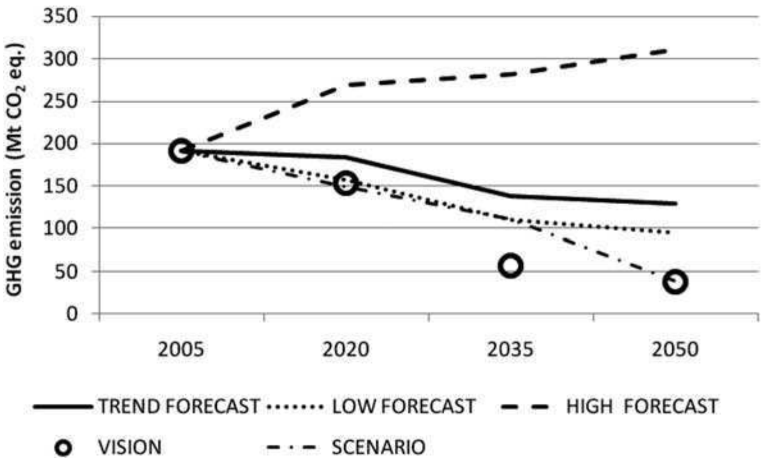

Fig. 8.1 GHG emissions scenario

As it can be seen the scenario is reaching the vision's targets in 2050, but not in 2035. The conclusion is that it will be very difficult to reach the "early mitigation target," i.e. to have a disproportionate reduction between 2020 and 2035. On the other hand from a political perspective, it might be helpful to take an "early mitigation approach," to keep the pressure and ensure reaching (the realistic target) for 2050.

In Fig. 8.2 the scenario, vision, and BAU forecasts are shown for fossil fuel share.

As it can be seen the scenario is reaching the vision neither for 2035 nor for 2050. It should be feasible to reach a 50% fossil fuel share by 2050, but a 40% share might be out of the scope. The conclusion is that also in a long-term perspective a high dependency on oil has to be expected.

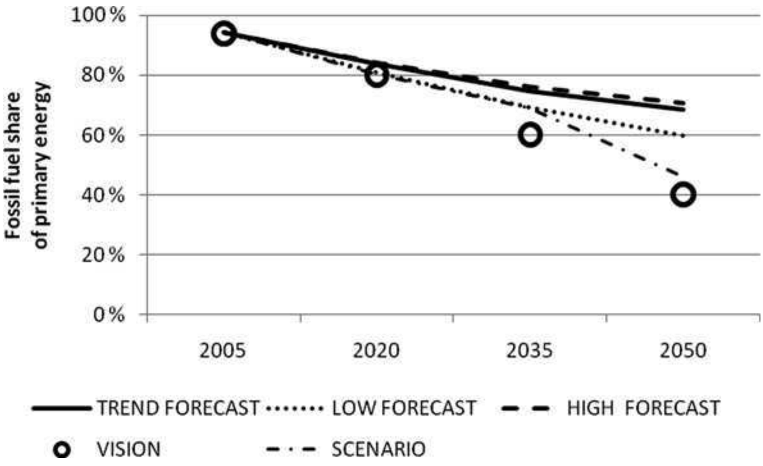

Fig. 8.2 Fossil fuel share scenario

8.2.2 Congestion

For backcasting of congestion the TRANS-TOOLS model was used. In the vision the target is to reduce the congestion level by 33% between 2005 and 2035.[3] In the BAU-trend forecast the congestion increased by 126% over this period of time. In the backcast the following input parameters of TRANS-TOOLS were adapted:

Road User Charge:

Definition: This parameter includes tolls both for passenger cars and for trucks. Passenger tolls have to be included, because road congestion is primarily influenced by passenger cars.

Assumed development (Tables 8.17 and 8.18):

Table 8.17 Scenario – development of road user charge passenger cars

Passenger cars				
	2005	2020	2035	2050
Toll cost	–	–	0.15 €/km	–

3 Only one backcast (for 2035) was calculated.

Table 8.18 Scenario – development of road user charge trucks

Trucks				
	2005	2020	2035	2050
Toll cost		–	0.3 €/km	–

Plausibility argument: In the trend forecast up to 2035, increases in GDP and car ownership are assumed. Therefore, it is necessary to apply actions which will reduce the future use of passenger cars and increase the utility of passenger cars to reduce road congestion. A road user charge will do the job to reduce the use of car and increase the occupancy rate. It is a more efficient action to reduce congestion than increase fuel prices, because the impact may be off-set by more fuel-efficient engines or use of electric engines. In the forecast, a flat toll cost of 0.15 Euro per km (2005-prices) for passenger cars on all roads was assumed, which is a significant increase in the marginal cost for using passenger cars. Depending on the actual fuel costs, it compares with an increase of 2–3 times the cost to use a car. For the sake of simplicity the same km-charge was assumed on all roads. Obviously, a more optimal strategy to reduce congestion would be to differentiate the charge depending on the level of congestion.

Plausibility argument: The truck user charge has been assumed to be the double of passenger cars for all roads, i.e., a flat charge of *0.30 Euro per km on all roads (2005-prices)*. In the forecast for 2035, costs of about 7 Eurocents per km in rural areas and 15 Eurocents per km on motorways and in urban areas was assumed.

Improved Road Logistics:

Definition: This parameter includes larger trucks and loading factors.

Plausibility argument: In the model, improved logistics efficiency was translated into an increase in truck load factor of 20% compared with 2005. It was not analysed how the improved efficiency eventually will be achieved, but it is expected that high truck-driving costs will lead to more optimal use of trucks with less-empty vehicles. The 20% level is not based on evidence, but used to indicate a significant and realistic improvement in truck utilization.

Road Infrastructure Usage

Assumed development: The Infrastructure was not changed in the backcast. (Same infrastructure as used in the forecast.)

Plausibility argument: However finally, it is assumed that road capacity overall is increased by 20% when compared with 2005. A larger capacity can be achieved by e.g., ITS, improved vehicle technology, and investments in road network. Studies show that break-down of traffic flow occurs at larger volumes today than, e.g., 20 years ago. For instance, the lane capacity of a motorway is about 2,300 passenger car units according to the Highway Capacity Manual (HCM 4), while it was assumed to be about

2,000 passenger car units 30 years ago. Historically, the increase in road capacity is contributed by many factors, e.g., improved vehicle technology (e.g. improved break technology), improved driver skills, improved roads, and speed regulations. Hence, an increase in road capacity of 20% could realistically be achieved over period of 30 years with moderate initiatives.

Results

The results from the backcast show that congestion can be reduced significantly, although the target of reducing congestion by 33% was not reached. *The backcast leads to a reduction of 26% until 2035.*

In the congestion scenario for 2035, transport performance is estimated to increase only 15% when compared with 2005. The lower increase in tkm in the scenario compared with the congestion forecast is mainly due to reduced transport distances, i.e., commodities are produced and sold closer to the marked. The change in transport behaviour and logistics is caused by higher road transport costs in the scenario compared with the forecast. The higher road charges in the scenario compared with the forecast is reflected in modal changes. Whereas tkm by road only increase few percents from 2005 to vision 2035, tkm by rail and inland waterways is predicted to increase about 50%.

8.2.3 Road Fatalities

The backcast of the road fatalities was based on the result of the congestion modelling, i.e., a 5% increase of road transport performance was assumed until 2035. In the vision it is targeted to reduce road fatalities by 65%. As there were 5,900 road fatalities with trucks involvement in 2005, the number of road fatalities with trucks involvement should be reduced to about 2,100. There were no models available to do a backcast on road fatalities, but with the assumed low transport performance growth in the congestion scenario, it should be possible to achieve the vision.

8.2.4 Comparison of the Congestion Scenario with the GHG/FFS Scenario

Congestion is dependent mainly on transport performance (here as a result of road user charges), infrastructure capacity and its efficient usage. Future development of GHG emissions and FFS depend on many more key characteristics like engine efficiency, biofuels share, aerodynamics and rolling resistance, engine technologies, etc.

This difference has of course impacts on the scenario development, as the congestion backcast is much more dependent on future transport demand development, whereas the GHG and FFS development can also be shaped by many other factors. The congestion scenario was therefore developed independently from the GHG/FFS scenario. The scenarios are therefore not consistent in their development:

- The congestion scenario is until 2035, whereas the GHG emissions/FFS scenarios are until 2050. (Therefore the numbers below are for 2035.)
- In the congestion scenario total transport performance increases by +15%, whereas in the GHG/fossil fuel share scenario transport performance increases by +43%.
- In the congestion scenario, road transport performance increases by 5%, whereas in the GHG/fossil fuel share scenario road transport performance increases by 33%.
- In the congestion scenario, rail transport performance increases by 50%, whereas in the GHG/fossil fuel share scenario rail transport performance increases by 70%.

It would have been easy to adopt the transport performance numbers from the congestion scenario into the GHG/FFS scenario as by doing so it would be much easier to reach the GHG and FFS vision. But the project team decided to stay with the higher numbers in the GHG and FFS scenario to show that even with higher transport performance numbers, it should be possible to reach the vision.

8.3 Scenario Assessment

The goal of the scenario assessment was to test the sensitivity of the GHG and fossil fuel share scenario. This should show where the most critical points of the scenario are and this was analyzed in the following ways:

- Firstly, the sensitivity of the scenario on the various key characteristics was tested,
- Secondly, the impact of each key characteristic was tested, and
- Thirdly, a list of wild cards[4] was collected, which might lead to a totally different future.

8.3.1 Sensitivity Analysis of the GHG Scenario

The idea of the sensitivity analysis is to check the impact of the development of an individual key characteristic on the development of the GHG emissions. This was done in the following way: it was assumed that all key characteristics, but one develop as targeted until 2050. For this one key characteristic, it was assumed it would stay at 2005 levels. Then the results of the two scenarios were compared and the size of the gap shows the sensitivity of the FREIGHTVISION scenario on this specific key characteristic.

An example may clarify the methodology: in the FREIGHTVISION scenario the following modal split was assumed for 2050: road 65%, rail 25%, and IWW 10%, i.e., a 6% points modal shift from road to rail and 4% points modal shift from road to IWW when compared to 2005.

To test how relevant this model shift is for the FREIGHTVISION scenario, a scenario was developed where no modal shift takes place. This scenario is called “NO

4 Wild Cards are low-likelihood, high impact, and hard to predict events.

modal shift-Scenario." It was developed the following way: all model key characteristics for 2050 were unchanged to the FREIGHTVISION scenario, but the modal split values were assumed to stay at 2005 levels (road 75%, rail 19%, IWW 6%). The model result shows that in this "NO modal shift-Scenario" the GHG emissions would be about 7% higher than in the FREIGHTVISION scenario, i.e., the sensitivity of the FREIGHTVISION scenario on modal shift is 7%.

Result:

This exercise was done for each key characteristic. The results of the sensitivity analyses are shown in Fig. 8.3.

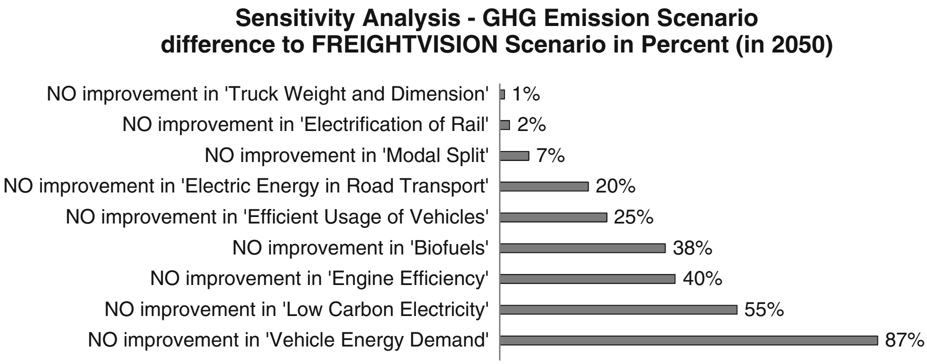

Fig. 8.3 Sensitivity analysis – GHG emissions scenario (in percent)

The number of percentage points means that the emissions in 2050 would be increased by that many percent, if the key characteristic stays at 2005 levels and all other develop as expected.

Figure 8.4 shows the sensitivities of the different key characteristics in CO_2 equivalents.

This assessment is an indicator of the relevance of the different key characteristics for reaching the goal and thus on which policy should concentrate.

- Figure 8.4 indicates that improvements in vehicle efficiency are by far the most important. If they stayed at 2005 levels, the GHG emissions would be about 90% higher than in the FREIGHTVISION scenario.
- The second most important key characteristic is improved electricity production (Low carbon electricity). But it has to be stressed that this relevance is only that high if other key characteristics like electric energy in road transport develop as assumed in the FREIGHTVISION scenario. If there is no electric energy used in road transport, low carbon electricity will be by far not that important. This methodological limitation is true for all of these sensitivity analyses.

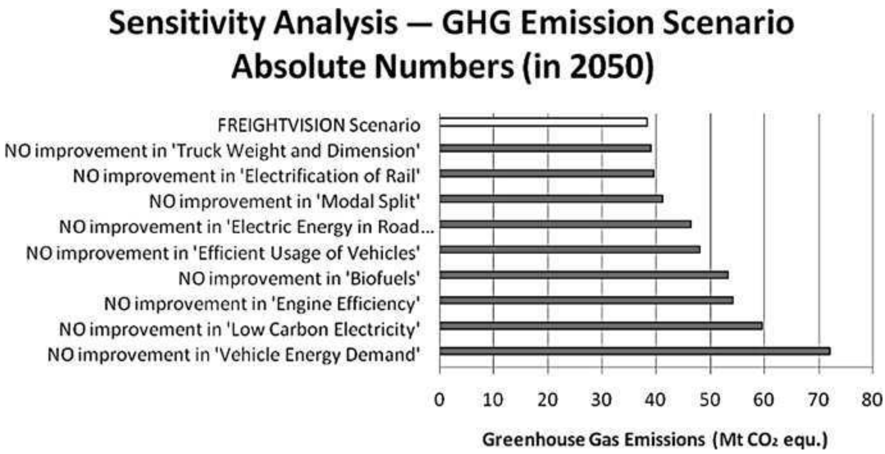

Fig. 8.4 Sensitivity analysis – GHG emission scenario (in Mt CO_2 equivalents)

- On the third place there are improved engine efficiency and improvements in biofuels (production's emissions and share of biofuels) with an equal high relevance.

At the lower end and thus not relevant for GHG emission reduction are two politically very much discussed topics modal shift ("modal split") and gigaliners ("truck weight and dimension"). Modal shift is not that important as the difference of the GHG emissions per tkm between road and rail are expected to decrease to the relationship 1:2. The efficiency increase by introducing gigaliners is even lower, although it was assumed that gigaliners produce 25% less emissions per tonne transported than smaller heavy goods vehicles (HGV), and that they could reach a market share of 10% (i.e. 10% of all transport performance is transported with gigaliners.)

8.3.2 Sensitivity Analysis of the Fossil Fuel Share Scenario

The same analysis was done for analyzing the impact on the fossil fuel share scenario. The results in percent can be seen in Fig. 8.5.

- The figure shows that by far the most relevant key characteristic is biofuels.
- Then there are two other key characteristics with a medium impact which are "Low Carbon Electricity" and "Electric Energy in Road Transport."

Both engine efficiency and electrification of rail have a very low impact. All other key characteristics have below 1% relevance and thus can be neglected for reducing fossil fuel share.

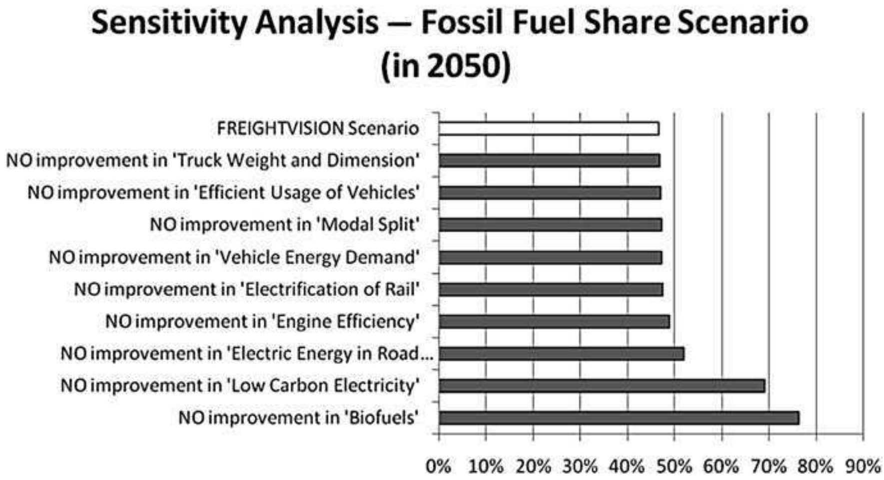

Fig. 8.5 Sensitivity analysis – fossil fuel share scenario

8.3.3 Impact Analysis GHG Emissions

The impact analysis is a complementary approach to the sensitivity analysis. In this analysis the following is assumed:

- All key characteristics stay at 2005 levels, whereas one key characteristic develops until 2050 as assumed in the FREIGHTVISION scenario.

An example is the scenario "ONLY improvement in Vehicle Efficiency" in which it is assumed that all other key characteristics like engine efficiency, biofuels, modal split, etc., stay at 2005 levels, but vehicle efficiency improves until 2050 as defined in the FREIGHTVISION scenario.

Figure 8.6 shows the result of the impact analysis. The results show the impact of an improvement of a certain key characteristic on its own:

- As can be seen in the figure, vehicle energy demand will have a very strong effect on reducing GHG emissions (−49%), even if no other key characteristic improves.
- In contrast improved electricity production (i.e. low carbon electricity) will not be very relevant (−2%), if other key characteristics fail to improve.

Figure 8.7 shows the results of the impact analysis in absolute numbers and compares them with the status 2005 ("GHG Emissions in 2005") and the FREIGHTVISION scenario.[5] From these numbers it can be seen that it is very important to focus on many

5 For the Impact Analysis and the FREIGHTVISION Scenario a transport performance growth of 44% until 2050 was assumed.

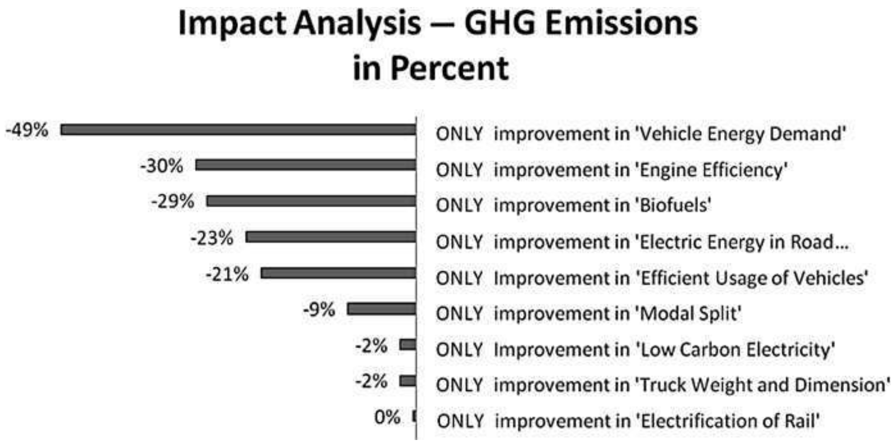

Fig. 8.6 Impact analysis – GHG emissions (in percent)

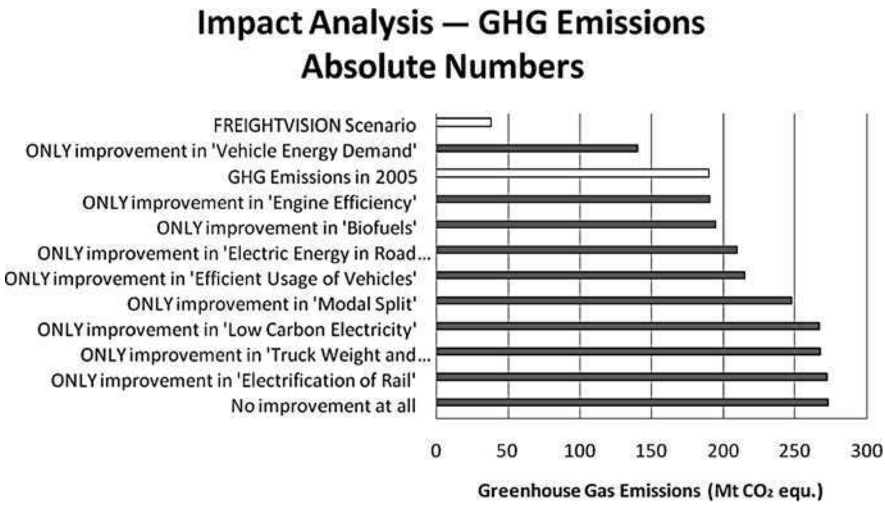

Fig. 8.7 Impact analysis – GHG emissions (in Mt CO2 equivalents)

key characteristics and especially to focus on the most effective ones. If policy focused, e.g., only on the introduction of gigaliners or modal shift, very limited effects can be expected, and emissions in 2050 might even be higher than emissions in 2005.

To address the discussions on modal split, its impact was analyzed with different scenarios.

Impact of Modal Split Scenarios

Modal split's impact is of course derived from the assumed modal shift: a higher modal shift to rail and IWW reduces emissions more than a lower modal shift. This special aspect was therefore analyzed in more detail: different modal split scenarios were developed and their impact analyzed.

The following modal split scenarios were assessed:

Scenario 1: This scenario assumes a very unfortunate development with regard to rail and IWW. It assumes that rail's and IWW's transport performance (tkm) stay at 2005 level. All additional transport is delivered by road. The growth of the each mode in percent and the modal split in 2050 is shown in Fig. 8.8.

Scenario 2: Modal split stays at 2005 levels. This assumes that rail and IWW will have the same growth in percent as road. For growth and modal split of this scenario see Fig. 8.9.

Scenario 3: This scenario assumes that rail and road will have about the same transport performance growth in billion tkm (road 410 billion tkm, rail 370 billion tkm). IWW is assumed to grow with 180 billion tkm, which corresponds to an ever stronger growth in percent. This is the modal split scenario assumed in the FREIGHTVISION scenario. The project team considers this scenario to be ambitious, but possible (Fig. 8.10).

Scenario 4: This scenario assumes an equal growth in IWW and rail in percent, and a much higher growth in rail. In absolute numbers the growth in road transport is about 400 billion tkm, rail is 530 billion tkm, and IWW is 30 billion tkm. This is a very optimistic scenario for rail transport (Fig. 8.11).

Scenario 5: Road tkm stay at 2005 levels, whereas all additional tkm are transported by rail and IWW. This scenario is considered by the project team as rather unrealistic, but this rail market share (above 30%) has been claimed by rail stakeholders as being realistic (Fig. 8.12).

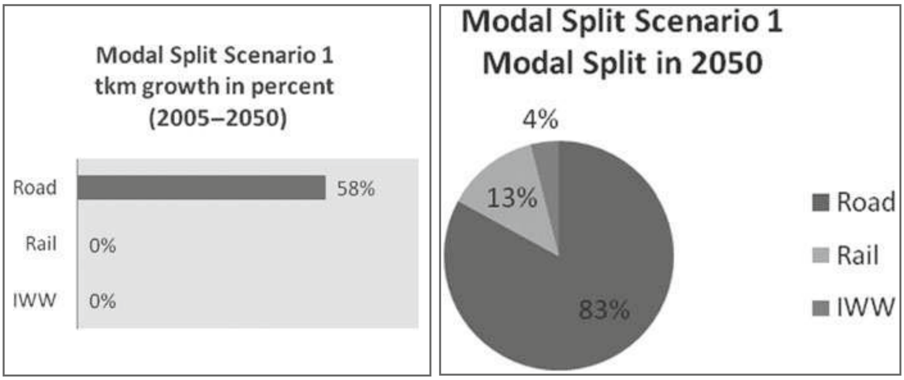

Fig. 8.8 Modal split scenario 1

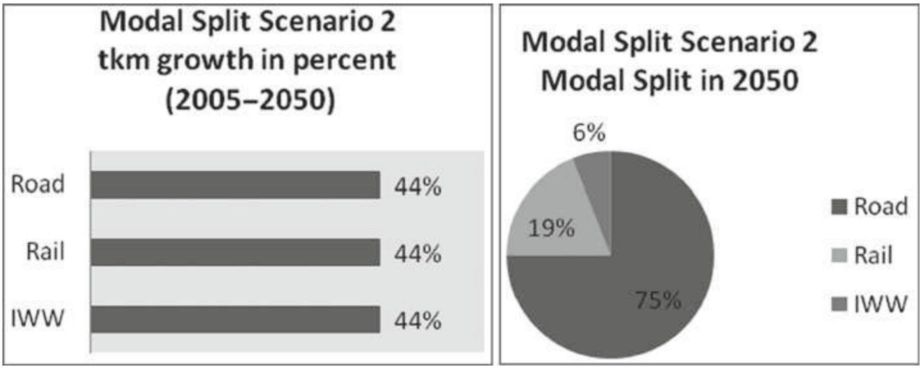

Fig. 8.9 Modal split scenario 2

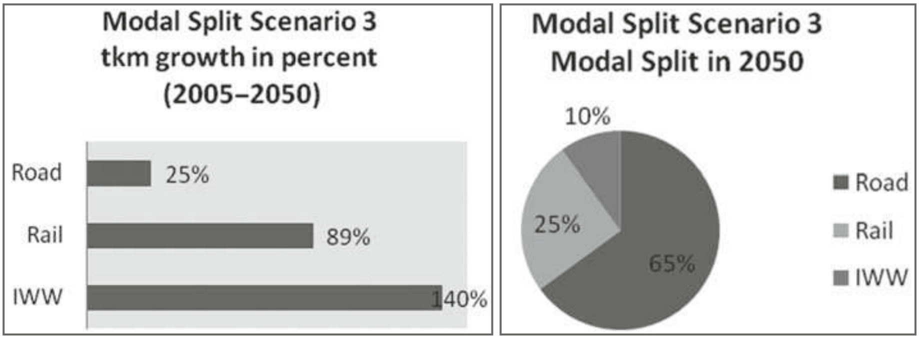

Fig. 8.10 Modal split scenario 3 (FREIGHTVISION scenario)

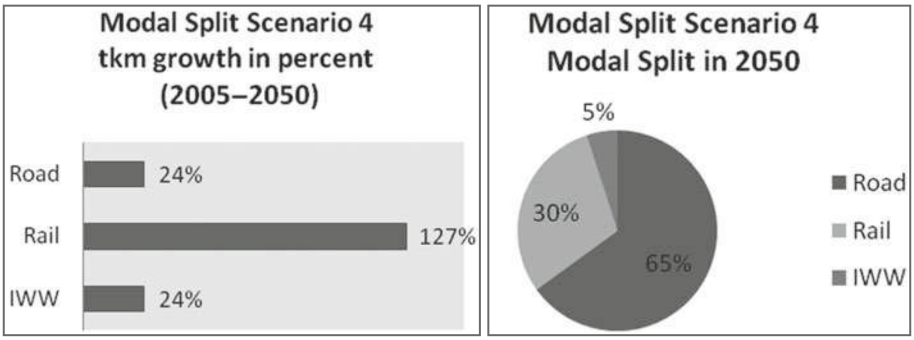

Fig. 8.11 Modal split scenario 4

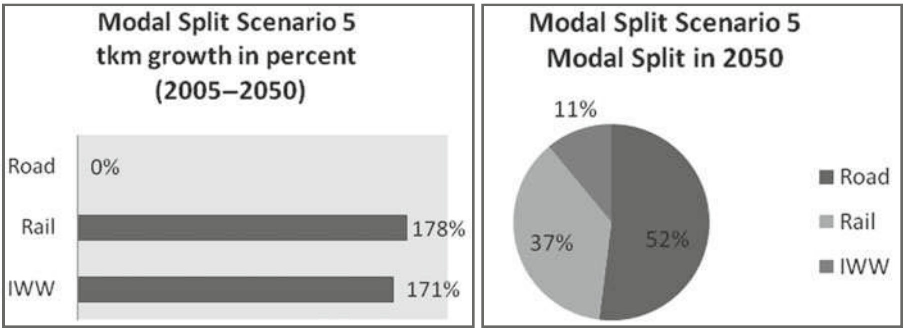

Fig. 8.12 Modal split scenario 5

Figure 8.13 shows the result of the impact analysis of the various modal split scenarios on GHG emissions. The impact analysis assumes that all other key characteristics (except Transport Performance) stay at 2005 levels, i.e., the impact analysis shows what the impact will be on GHG emissions in 2050, if only modal split improves. It is of course up to political decision-makers which modal split target they define, but what can be seen is the possible impact of these different scenarios. This is especially interesting if policy strategy is to focus on rail transport for reducing emissions and neglecting the development in road transport.

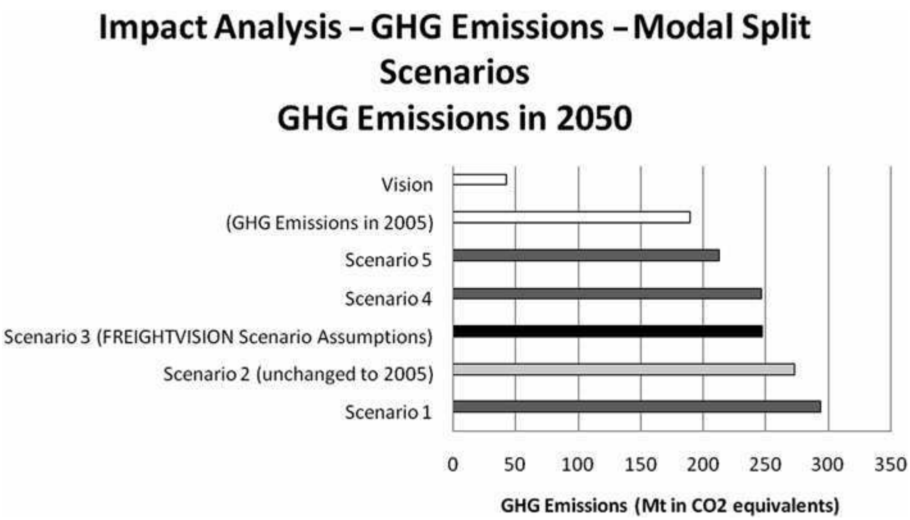

Fig. 8.13 Impact analysis on GHG emissions – modal split scenarios (in Mt CO2 equivalents)

Figure 8.13 also includes for comparison reasons the vision for 2050 and the GHG emissions in 2005.

As can be seen by these numbers that even, if scenario 5 became true, the GHG emissions would still be above 2005 levels. The "plausible" modal split scenarios (2–4) show that the impact is relatively limited compared to the vision defined.

The conclusion from this impact analysis is that it should be avoided to have too high expectations on modal shift's impact on reducing GHG emissions.

8.3.4 Comparison of Impact and Sensitivity Analysis

On Fig. 8.14 the results of the impact and sensitivity analysis are opposed. By comparing them it can be seen, if a certain key characteristic depends on the development of another key characteristic.

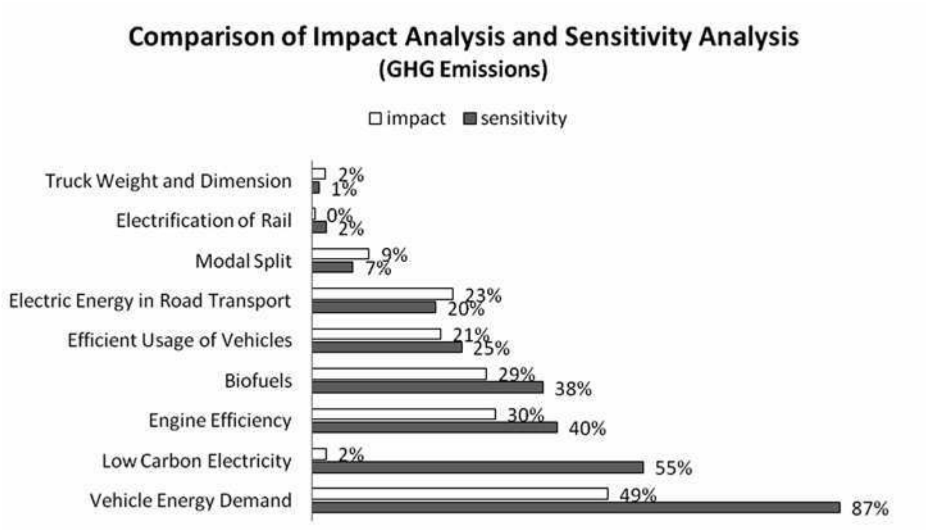

Fig. 8.14 Comparison of impact and sensitivity analysis (GHG emissions)

As can be seen the results of the impact and sensitivity analysis are quite similar. The main difference is in "Low Carbon Electricity" which has a low impact, but the scenario is very sensitive on it. This is because electricity production will be only relevant for transport's GHG emissions, if electricity is used in road transport.

As the impact analysis and the sensitivity analysis do not differ a lot, the conclusion is that the importance of the key characteristics can be seen in the sensitivity analysis. According to this analysis the ranking is (Table 8.19):

Table 8.19 Priorities of key characteristics

Priority	Key characteristic
1	Vehicle efficiency
2	Low carbon electricity
3	Engine efficiency
4	Biofuels
5	Efficient usage of vehicles
6	Electric energy in road transport
7	Modal split
8	Electrification of rail
9	Truck weight and dimension

8.4 Wild Cards

In one of the Forum Meeting, wild cards were collected. Wild cards are low-likelihood, high impact, and hard-to-predict events. Wild cards are interesting as they can show a much broader future development and this can show the vulnerabilities of the scenario. Of course it is not possible to consider all of them, because the number of scenarios would be much too high.

For each key characteristic the relevant wild cards are

Transport Demand

Equalized labour cost, energy price increase, protectionism, economic crises, local production, pandemic, terrorism, restriction of global trade, failing states in the direct neighbourhood, home production, mass migration, growth faster out of recession, manufacturing costs are balanced/relocalisation, virtualisation of production, ban or restriction of rare earth metals, shortage of resources leads to decreasing mobility solutions, failure of climate change mitigation negotiations, war for water, economic crises, local production, breakup of the EU, civil war, rising sea levels (frequent flooding);

Vehicle Efficiency

Coordination of action within EU, high oil price, heavy weather conditions, energy price increase;

Engine Efficiency

Peak oil, energy price increase;

Biofuels

Nuclear fusion, availability of alternative energy, war for resources, biofuel production leads to social unrest, high oil price, cheap available oil, breakthrough in biofuels (e.g. algae), energy price increase;

Electric Energy in Road Transport

War for resources, energy war, radical reduction of carbon cost, nuclear batteries, nuclear disaster, high oil price, 50% solar power share, solar storm cause Galileo and power supply etc. to fail (less electric), nuclear fusion, breakthrough in biofuels (e.g. algae), energy price increase;

Electric Rail

Energy price increase;

Truck Weight and Dimension

Modal Split

More environmental criteria, earth quake on major axis, automatic full platooning, automatic guided vehicle; extreme weather conditions cause truck traffic to stop;

Efficient Usage of Vehicles

Automatic full platooning, automatic guided vehicle, energy price increase;

As can be seen from the above list, most wild cards are about external factors causing transport demand changes. These external wild cards are mainly macroeconomic, environmental or political. Not many technological or organizational breakthroughs were mentioned, neither of the transport nor the production system.

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Part IV
Recommendation

9 Policy Actions

Stephan Helmreich, Martin Volny, and Carine Vellay

Abstract FREIGHTVISION, 35 policy actions were identified to influence the freight transport system with regard to the project's four sustainability criteria. These actions are related to road transport, rail transport, IWW and maritime transport, supply chain, energy supplier and vehicle supplier. The analysis of each action covers experience and feasibility, potential impact on each of the four sustainability criteria, pro and contra arguments, RTD and transport policy tasks, milestones and a conclusion. This chapter summarizes this analysis.

9.1 Introduction

Public policy is a system of actions taken by governmental entities concerning a given topic. In FREIGHTVISION's case the 'system of actions' consist of research and technology development (RTD) and transport policy actions, the 'governmental entity' is the European Commission Directorate-General for Energy and Transport, and the 'given topic' is a sustainable transport system. The policy actions are combined in the next chapter to an "action plan", which should enable that the FREIGHTVISION scenario will come true.

In the project 35 policy actions were identified and grouped into the following categories:

- Road transport
- Rail transport
- IWW and maritime

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- Supply chain
- Energy supplier
- Vehicle supplier

Originally in the management summary prepared for the 2nd Forum Meeting 60 actions were listed. This list of 60 actions was reduced to 35 actions as some actions were combined and others seemed to be not so relevant.

These 35 actions were analyzed by desk research. As far as possible, the consortium tried to highlight different and conflicting literature/studies on each topic. The result of this analysis is presented on the following pages. The actions are

Road transport related actions

1. Investment in ITS
2. Investment in road infrastructure
3. Internalization of external costs
4. Modifying the rules for HGV weights and dimensions
5. Liberalization of cabotage
6. Progressive distance pricing
7. Different pricing with regards to type of freight
8. Harmonized speed limits
9. Congestion charge
10. Enforcement of regulations

Rail transport related actions

11. Investment in rail infrastructure
12. Freight prioritization
13. Funding for ERTMS / ETCS
14. Electrification of rail corridors
15. Longer trains
16. Heavier trains

IWW and maritime transport related actions

17. Investment in IWT infrastructure
18. Develop new technologies in IWW
19. Investment in maritime port infrastructure

Supply chain related actions

20. Training for eco-driving
21. Automated platooning
22. Standardized loading units
23. E-freight
24. Network optimization – cargo owner
25. Network optimization – logistics service provider
26. CO_2 labels

27. Intermodal transport
28. Transport consolidation and cooperation
29. Transport route planning and control

Energy suppliers related actions

30. Taxation of fossil fuels
31. Hydrogen infrastructure
32. Improved batteries (energy storage)

Vehicle supplier related actions

33. Including CO_2 standards into HGV regulations (EURO 6)
34. BAT vehicle certification for heavy goods vehicles
35. Clean vehicle technologies

The analysis of each action has the following structure

- Introduction
- Assessment
  - Experience and feasibility
  - Market perspective
  - Potential
  - PROs and CONs
  - Conclusion
- Recommended tasks and milestones[1]
  - RTD policy
  - Transport policy
  - Milestones

Experience and Feasibility

'Experience and feasibility' refer to the implementation of the analyzed actions in European countries or outside the European Union (when the action has not been applied yet within Europe).

Feasibility encompasses:

- Social feasibility: the environmental and societal issues, like effects on flora and fauna, visual influence and social equity,
- Economic feasibility: the impact of the action on economic growth,
- Political feasibility: analyzing whether there will be a high and powerful resistance from interest groups against this action,
- Technical feasibility: the main technical issues including costs.

1 If the assessment resulted in not recommending this action, then RTD, Transport Policy and milestones are not elaborated.

Potential

'Potential' refers to the potential impact of an action on each sustainability criterion. As the impact cannot be quantified in total numbers, the project team has agreed to compare the actions' impact with a rating scheme.

The rating scheme is

- '– – –' strong negative impact
- '– –' medium negative impact
- '–' slight negative impact
- '0' no impact
- '+' slight positive impact
- '+ +' medium positive impact
- '+ + +' strong positive impact

In some cases there are also ranges (e.g. '– to ++') stated as there are different opinions on the actions' impact in the literature.

PROs and CONs

The most relevant pro and contra arguments for each action are listed in the PROs- and CONs- tables.

Conclusion

The final part contains a conclusion. Some conclusions contain a recommendation which takes into account the potential impact on all sustainability criteria and the pro and contra arguments. For the final conclusion the following 3 levels are used:

Not recommended

- No positive impact on one (or some) of the 4 sustainability criteria or
- Positive impacts on one (or some of the 4 sustainability criteria), but there are severe disadvantages from other points of view (e.g. economic growth, social aspects).
- The disadvantages outweigh the advantages.

Recommended

- Moderate positive impacts on one (or some) of the 4 sustainability criteria or
- If there are high positive impacts on one (or some of the 4 sustainability criteria, but there are disadvantages from other points of view (e.g. economic growth, social aspects);

- In total the positive impacts outweigh the negative impacts

Highly recommended

- High positive impact on one (or some) of the 4 sustainability criteria, and
- No or very limited disadvantages

Market Perspective

Who is affected by this action and what is their position on it.

RTD Policy

Is there a demand for RTD policy tasks? This includes all kinds of RTD tasks like basic research, applied research and demonstration projects.

Transport Policy

Is there a demand for transport policy tasks, both on national and European level?

Milestones

What progress should be achieved by 2020, 2035 and 2050?

9.2 Action 1 – Investment in ITS

Jürgen Schmiele and Ulrich Glöckl

9.2.1 Introduction

Intelligent Transportation Systems (ITS) consist of a wide variety of systems: variable message signs (VMS), ramp metering, pre- and on-trip information, temporary hard shoulder running and collision avoidance systems (namely lane guard warnings and adaptive cruise control).

Historically, Intelligent Transport Systems (ITS) have reduced the frequency and severity of road fatalities and congestion due to more harmonized speed limits and assistance systems. In future they will assist in providing high-quality transport network information, reduce the human error in driving; and they are a core element for the application of many policies.

Related actions are internalization of external costs (#3), congestion charging (#9), transport route planning and control (#29).

9.2.2 Assessment

Experience and Feasibility

ITS are installed on many critical segments and in many vehicles already today.

ITS have been assisting in easing transport problems in the past and will continue to do so in future. It has been shown that especially road fatalities and congestion can be tackled. Temporary hard shoulder running permits to increase the capacity during periods of high demand. Its implementation is faster and more affordable than an ordinary capacity extension. It indirectly reduces congestion by offering additional capacity. VMS informs drivers about warnings, alternative routes and speed limits. It reduces road fatalities and harmonizes traffic flow.

Road tolling systems should be harmonized within Europe for interoperability reasons for international road transport. A similar harmonization should take place for lane markings, because many driver assistance systems rely on video detection. The importance is growing because new technologies, like floating car data and vehicle-to-vehicle communication, permit to inform drivers and take action autonomously in case of emergency. Furthermore, they are considered to be a core element in smarter pricing schemes in future. ITS applications such as automated platooning (Action 21) are based on typical ITS applications.

Different new options may develop with more precise Global Navigation Satellite Systems (GNSS), because it will permit to track and trace freight more accurately. It may also be the fundament of new technologies such as “intelligent containers” that seek autonomously their routes and modes between origin and destination. Intermodal and comprehensive information networks are inevitable for such developments.

Various ITS research programs are developing new applications. As of today most systems significantly decrease the number of road fatalities, and therefore also incidents that can lead to congestion.

Company/Market Perspective

Road-side infrastructure for ITS applications is publicly financed. Services and technologies from private companies are likely to gain momentum and contribute to an increasing importance, e.g. for safety systems as well as traffic and routing information. With improved data, the willingness to pay is likely to increase.

Reduction Potential

Table 9.1 Reduction potential – investment in ITS

GHG	+
FFS	0
Road fatalities	+++
Congestion	+++

Pro Arguments:

- Reduction of human errors and thus reduction of road fatalities.
- Harmonization of traffic flow and thus reduction of road fatalities and congestion.
- Increase in capacity and significant reduction in accident-related congestion.
- Smoothening of traffic peaks.
- High potential for future policy implementation (cf. internalization of externalities, congestion pricing, tracking and tracing, etc.).

Contra Arguments:

- Infrastructure-based systems only in metropolitan areas.
- Increased capacity attracts additional traffic.
- Critical masses necessary in order to deliver full potential.
- Product liability.
- Drivers have to accept their smart 'assisting driver'.
- May counteract modal split policies.

Conclusion

ITS assist in easing future challenges, but they cannot solve them by themselves. They can deliver important reductions on congestion and increase traffic safety. Regarding GHG emissions, their impact is very limited and on fossil fuels share there is no impact. More detailed scientific studies on the effect on GHG emissions should be carried out, because it remains unclear. VMS and ramp metering can keep traffic flow stable and are recommended. Highly recommended are temporary hard shoulder running and collision avoidance systems reducing road fatalities and congestion drastically. ITS are considered to be a very important element for future pricing schemes as well as information and guidance opportunities for freight transport. Information systems in future should integrate different modes to permit smart decisions.

Highly Recommended

9.2.3 Recommended Tasks and Milestones

RTD Policy

- Quantification of the potential of GHG emission reduction due to information.
- More intermodal dynamic (route) planning systems to create intelligent freight transport chains.
- Effects of time and route sensitive road pricing on (secondary) road network.

- Satellite information for road transport and integration with planning systems.
- Pooling of freight transport supply & demand.
- Possibilities and chances of real-time intermodal transport information for freight forwarders.
- Integration of system architectures for comprehensive transport data pooling.

Demonstration Projects:

- Application of Advanced Driver Assistance Systems (ADAS) to increase road safety.
- Tracking & tracing using Galileo.

Transport Policy

Some aspects limit exploiting the full potential of information-based systems, or prevent their extensive application. Proper policy action should enable using their full benefits.

European Transport Policy

- Solving product liability
- support for more automated transport systems
- stronger emphasis on road safety mitigation (e.g. legal requirements)
- support for EU-wide (intermodal) transport information

Milestones

By 2020:

- Provision of technology for transport pricing policies
- Probable mandatory active brake assist and lane guard systems for new HGV starting in 2013 (COM(2008)316)
- ICT in transport offers high quality intermodal transport information

By 2035:

- Broad application of co-operative safety systems
- Reliable pan-European intermodal transport information and short term projections for all modes

9.3 Action 2 – Investment in Road Infrastructure

Carina Botoft, Søren Saugstrup Nielsen, and Helena Kyster-Hansen

9.3.1 Introduction

The investments decided upon as regards the trans-European network include upgrading of lines as well and higher speeds on parts of the existing network. Many of the TEN investment plans concern projects for railways, and here mainly for high speed passenger lines. In the long perspective some new roads will probably be built in some areas of Europe, especially where the roads are in a condition that is of a very low standard, e.g. Romania and Bulgaria.

Some investments in infrastructure will probably be made in areas where congestion is high, e.g. in Germany, the Netherlands and Belgium. But it is not likely that it will be possible to build many new roads or motorways in these areas because of the scarcity of land. Therefore the main purpose will be to reduce capacity shortage and road condition bottlenecks in the European road network.

The TEN road network is essential for the overall freight flows in Europe. Investments in the TEN-T should focus on removal of bottlenecks, linking networks of all modes of transport and better utilization of the existing network by using e.g. ITS. At the same time, it is necessary to have a holistic approach to the transport system as a whole. Introduction of Green Corridors is an opportunity for combining actions and a holistic approach. There is also a need to include the connections to the non-EU countries.

9.3.2 Assessment

Experience and Feasibility

Many examples show that when building new roads in heavily congested areas, it takes only a few years time to reach the capacity limits for the new road. The result is congestion on the new road and thus the new road does not solve the problem with too much traffic on the existing road network. Reduction of bottlenecks in the road network is a very important focus, and even more so in the future. Maintenance of the existing roads is important to keep in focus, since suspension of maintenance of the roads can lead to very high extra costs. Therefore, there should be adequate investments in the maintenance of roads.

Company/Market Perspective

Investments in road infrastructure affect all stakeholders, including road users, industry, transport operators and infrastructure managers. As investments can reduce the cost of transport, most commercial stakeholders are in favour of new investments.

Reduction Potential

Table 9.2 Reduction potential – investment in TEN network – road

GHG	+
FFS	0
Road fatalities	+
Congestion	++

Pro Arguments:

- Investments in infrastructure (new roads) can lead to a better trans-European network in some areas in Europe
- New roads can handle the increasing volumes in Europe
- Removal of bottlenecks in the European road network will reduce the congestion as well as emissions

Contra Arguments:

- In transport corridors with high levels of congestion and pressure on land use, it is difficult to find space to build new roads.
- New roads will reduce the congestion for the first period of time, but eventually the congestion will return to same levels or higher levels.

Conclusion

Reduction of bottlenecks in the road network is a very important focus. It is thus recommended to reduce bottlenecks in the TEN network-road, and to combine these efforts with congestion charging.

Recommended

9.3.3 Recommended Tasks and Milestones

RTD Policy

- Collect and use knowledge on how to remove bottlenecks, with a holistic approach and usage of, e.g., ITS and multimodal terminals.
- Use knowledge to develop new ITS solutions and new ways of using the network, e.g. prioritized freight lanes/corridors.
- Develop new road, junction and hub design to counteract congestion.

Demonstration Projects

- Green Corridor demonstration projects with electric supply infrastructure should be introduced, to show which effect a holistic multimodal approach could have on freight transport.

Transport Policy

The TEN networks are presently under revision and the current governance regime is that the EU supports the TEN investments, which mainly are proposed by the member states, but the member states still finance the bulk of the investments, and therefore they are the key decision-makers.

European Transport Policy

Co-ordination and prioritisation in eliminating bottlenecks and creating an integrated multi-modal network for freight transport, new investments focusing on GHG reduction.

National Transport Policy

Focus on completing the revised TEN projects and ensure freight flows on the national and regional road network and their connection to the TEN road network.

Milestones

By 2020:

- An integrated multimodal approach to TEN road network has been implemented and the goal for a core and comprehensive network has been implemented, including both geographical and conceptual pillars on how to invest, and a demo model of a Green Corridor with electric supply infrastructure.

By 2035:

- The bottlenecks in the TEN road network have been relieved, and a multimodal core TEN network has been established, including a few Green Corridors with electric supply infrastructure.

By 2050:

- The TEN network consists of a fully integrated, multimodal network, with good access to the entire network, fully expanded electric supply infrastructure on TEN network.

9.4 Action 3 – Internalization of External Costs

Nihan Akyelken, David Bonilla, and Olaf Meyer-Rühle

9.4.1 Introduction

Internalization of external costs of transport has been an important issue on the EU agenda since the publication of the 1995 Green Paper on efficient pricing of transport. External costs are the utilisation of resources for which the user (causer) does not pay any compensation, in other words, they are costs, which traffic participants are inflicting on third persons. Vehicle operating costs (VOCs) and transport time costs are fully born by transport users. The objective of this action is that all other costs, i.e. the infrastructure, environmental damages and those accident costs, which are not covered by the users' insurance are to be borne by them. The current "Eurovignette" Directive assures the full internalization of infrastructure costs. The importance of efficient pricing/taxation is scientifically endorsed and relates to all modes and types (passengers, freight) of transport. More recently, the Commission classifies congestion costs as external costs which is contested by scientists, as far as VOCs and time costs are concerned.

The internalization of external costs means to make externalities part of the decision-making process of transport users.

9.4.2 Assessment

Experience and Feasibility

The main focus has been on charging heavy-goods vehicles. The vignette system has been replaced in certain EU member states by distance-based charges albeit with wide differences in application. Switzerland, a non-EU country, has introduced in 2001 a charging system which now makes all HGVs over 3.5 t GVW pay all costs including external costs on all roads on Swiss territory. Here, the build-up of the charge in three steps over 8 years has not produced a significant inflationary pressure nor has it had the expected effect of a major modal shift of freight to railways.

Company/Market Perspective

Logistics and freight companies and vehicle suppliers would be negatively affected as they now have to pay for the costs to third parties. They could also be affected positively through the reduction of negative effects. The action may be beneficial for infrastructure managers, if additional revenue is used for public investment.

Reduction Potential

Table 9.3 Reduction potential – internalization of external costs

GHG	+++
FFS	+
Road fatalities	0
Congestion	+

Pro Arguments:

- An action to correct market failures
- Contributes to a fairer society
- Revenue generation to cover or mitigate external costs
- Feasibility proven

Contra Arguments:

- High costs of implementation
- Needs harmonization at the EU level
- Action to be applied to all types and modes of transport

Conclusion

The objective of fairer pricing in transport should be applied to passenger and freight transport on all modes. The introduction for HGVs is easier in the political arena. As a first step, the action is

Recommended

9.4.3 Recommended Tasks and Milestones

RTD Policy

The main RTD policy relevant for the action should deal with reducing the high implementation costs of the action and calculation of the external effects. This requires research on new technologies that may reduce the costs of the action's implementation, including the use of satellite positioning and real-time measurement of relevant external effects.

Basic research is required for identifying the regions, where there is high level of external costs and where the action threatens the European competitiveness and regional cohesion.

Transport Policy

The latest Eurovignette Directive issued by the EC in 2006 allows variation in tolls to reflect congestion and air pollution. The current rail infrastructure charging directive (Directive 2001/14/EC) allows charging for external effects in certain cases. The Greening Transport Package (2008) proposed to amend the Eurovignette Directive by removing the current prohibition of 'external cost charging'. Directive 2004/52/EC provides a framework for the interoperability of toll collection systems within the EU (EETS); it entered into force in October 2009 and requires the Member States follow an EU-wide system for HGVs within 3 years.

European Transport Policy

EC should propose a directive for harmonizing policies in all modes of transport using the same criteria and the level of ambition (with a particular focus on the measurement of external effects and a common system of determining the costs attributed to them).

National Transport Policy

Member States should be subject to harmonization of national schemes with the rest of the EU.

Milestones

By 2020:

- Basic field research for identifying regions where there is high level of external costs and for reducing the high implementation costs as well as harmonization of national schemes

By 2035:

- Research on mapping of external effects followed by full coverage of the TEN-T network where relevant.

By 2050:

- Those technologies and the common framework should be deployable throughout the entire networks of EU Members States, where applicable, and all external costs should be internalized at all modes.

9.5 Action 4 – Modifying the Rules for HGV Weights and Dimensions

Olaf Meyer-Rühle, Ronald Jorna, and Hans Zuiver

9.5.1 Introduction

The objective of this action is to allow longer and/or heavier HGVs on parts of the road network in the European Union. Directive 96/53/EC regulates weights and dimensions of HGVs within the territory of the EU. Member States are entitled to allow longer and/or heavier trucks (LHV) to circulate in their country, provided that this does not affect international competition. International transits are not allowed. The EC is considering the implications of allowing the use of LHVs, measuring up to 25.25 meter and/or weighing up to 60 tonnes, for the whole European transport system.

9.5.2 Assessment

Experience and Feasibility

Until recently only Sweden and Finland made use of this possibility. Tests are now undertaken in Denmark, The Netherlands, and the German states Thuringia and Mecklenburg-Western Pomerania. Belgium and France have expressed interest in testing this concept. On the other hand, countries like Germany, Austria and the UK as well as several others have said "no" to LHVs. In their views LHVs are perceived to produce a lot of CO_2, form a threat to the competitive position of the rail sector and have a negative influence on road safety. LHVs of 60 tonnes are also expected to require investments in the existing road infrastructure.

Company/Market Perspective

The positions of road hauliers and their associations and federations are mixed. An assimilation of presently allowed weights and actions to a European Modular System (EMS) does not pose a commercial problem where suitable transport demand exists. However, the impact on modal shift is unclear at this stage. Tests on international pilot corridors are recommended to test market reactions.

Reduction Potential

Table 9.4 Reduction potential – modifying the rules for HGV weights and dimensions

GHG	– to ++
FFS	– to 0
Road fatalities	– to +
Congestion	+

Pro Arguments:

- Decrease of operational costs due to higher efficiency
- Decrease of emissions depending on the real effect on modal shift
- Fewer trucks for the same amount of goods transported
- Positive influences on road safety and emissions
- Member States set the network where these trucks are allowed

Contra Arguments:

- Reduced cost will generate more demand for road transport
- Improved competitive position versus rail and IWT
- Increased emissions, congestion and negative impacts on safety
- Investments needed in road infrastructure for heavier vehicles
- If road fatalities occur, the damage might be higher due to weight

Conclusion

The future of LHVs in Europe is still uncertain, and it will take some time before a final decision can be made on the European level. DG TREN has meanwhile commissioned a new technical and economic study on the subject.

No preference due to contradicting studies. Recommendation for further impact assessment of the three alternatives (longer, heavier, longer and heavier)

9.5.3 Recommended Tasks and Milestones

RTD Policy

On the side of the vehicles, no new technology is necessary. Additional safety requirements may be imposed.

Only parts of the infrastructure may be permitted for EMS vehicles (e.g. motorways and similar highways, UNECE classified E-roads, EU classified trans-European road network). Bridges may have to be reinforced and other infrastructures may need adjustments. Public yards for recomposition of EMS vehicles are needed.

There is no need for specific technological research, but on aerodynamics improvements as well as on crashworthiness and braking characteristics of HGV.

Demonstration Projects

- Monitoring and impact assessment of an international pilot corridor scheme

Transport Policy

National governments can decide to permit longer and heavier vehicles (LHVs) within the boundaries of their jurisdiction. Cross-border operations require EU regulation.

European Transport Policy

Pending further impact assessments and possibly pilot corridor tests, the European Commission has not yet made formal proposals for intra-EU cross-border operations of LHVs. It is possible that not all or only a smaller group of Member States agree to an EMS.

New regulation of HGV actions and weights will require additional legislation on the operation of such vehicles.

National Transport Policy

The subsidiarity principle allows national governments to open parts of their road networks for EMS vehicles. Most MS governments, apart from Finland and Sweden, have so far been reluctant to do this; tests on national territory only are allowed in certain Member States.

Milestones

By 2020:

- Regulations for the EMS are expected to be in place, unless disagreements between Member States prevent the system from becoming operational.

9.6 Action 5 – Liberalization of Cabotage

Olaf Meyer-Rühle and Kristin Stefan

9.6.1 Introduction

Cabotage is defined as domestic transport (between two points in the same Member State) by an operator from another Member State. Road cabotage is regulated by the EU by EU regulation ECC 3118/93 but has been liberalized step by step since 1994. It is allowed on a "temporary" basis to prevent abuse (exception: precarriage and postcarriage of combined transport according to Directive 91/106). A harmonization of rules will become into effect in May 14th, 2010 (EC regulation 1072/2009).

The action should also apply to rail and inland water transport and short-sea shipping.

9.6.2 Assessment

Experience and Feasibility

Under present legal restrictions and according to Eurostat data, EU hauliers performed in 2006 about 16 billion tonne-kilometres (tkm) of road cabotage operations representing about 0.8% of total and ca. 1.2% of domestic road haulage performance.

Hauliers from six countries operate two-thirds (67%) of total EU cabotage: Germany (2.3 billion tkm), Netherlands (2.2), Luxemburg (2.1), Belgium (1.6), Poland (1.3) and Italy (1.0). The BENELUX countries, centrally located between Germany, France and the UK, combine 6 billion tkm or almost 40% of total EU cabotage. On the other side, three out of four (75%) cabotage tonne-kilometres are performed in five countries: France (4.3 billion tkm), Germany (3.2), UK (1.7), Italy and Spain (1.0 each). The size of a country is of course the main factor. Partly it is an unbalanced situation, e.g. France (large country; high labour costs): foreign operators perform 4.3 bn tkm in France while French operators perform only 0.5 bn tkm abroad; Luxemburg (small country; active in international transport): 0.02 and 2.1, respectively.[2]

The action is feasible.

Company/Market Perspective

The most relevant market players affected by this action are road hauliers, shippers and consumers of good transports.

- In principle road hauliers and shippers could use the capacity of their trucks better and reduce empty running. Due to different situations in countries of the European Union (EU) concerning, e.g., labour costs (high vs. low) and their geographical positions within the EU (central vs. peripheral), the attitude of road hauliers and shippers will depend on if they could take an advantage of liberalization or not.
- For consumers, prices of good transports could decrease due to reduced empty running and increased competition.

Reduction Potential

Table 9.5 Reduction potential – liberalisation of cabotage

GHG	++
FFS	0
Road fatalities	+
Congestion	+

Pro Arguments:

- Reduction of empty driving
- More efficient transport and use of vehicles
- Less vehicle-km and hence less operating costs, emissions etc.

2 Cf. Eurostat: Trends in road freight transport 1999-2007, Statistics in Focus, Transport, 8/2009 and Eurostat: Competitiveness in EU road freight transport – 2006, Statistics in Focus, Transport, 97/2008.

- Strengthening of competition
- Cheaper transport

Contra Arguments:

- Lack of harmonization
- Abuse by operators from cheap labour countries
- Abuses difficult to monitor; lack of law enforcement
- Peripheral countries are disadvantaged
- Possible market distortion

Conclusion

Full liberalization of cabotage is only suitable if cannibalization of domestic transport markets can be excluded (precondition: convergence of vehicle operating costs, in particular labour costs). We consider that a market penetration of 2% can be absorbed without significant market distortion.

Recommended

9.6.3 Recommended Tasks and Milestones

RTD Policy

This action does not depend on technologies at all. There is no need for research and demonstration projects.

Transport Policy

Road cabotage is regulated by the EU by EU regulation ECC 3118/93 but has been liberalised step by step since 1994. It is allowed on a "temporary" basis to prevent abuse (exception: precarriage and postcarriage of combined transport according to Directive 91/106).

European Transport Policy

A harmonisation of rules will become into effect in May 14th, 2010 (EC regulation 1072/2009), limiting cabotage trips to 3 within 7 days and up to 3 cabotage trips (1 only per country) on the way back to the home country. In case of proven serious market disturbance in inland transport, European Member States can apply for additional restrictions to the European Commission. But a definition of serious market disturbance does not yet exist.

Finally in a European single internal market, where everything is allowed to move freely, transport operators should too.

National Transport Policy

National governments cannot avoid cabotage, because EU law is community law and has to be obeyed.

Milestones

By 2020:

- FREIGHTVISION team assumes that by 2020 cabotage will be fully liberalized within the European Union with a market penetration of 2% of domestic road haulage performance (2006: 1.2%).

9.7 Action 6 – Progressive Distance Pricing

Carine Vellay and Martin Volny

9.7.1 Introduction

The action is aiming at progressive charging of freight depending on the total distance travelled. This action should not take into account external costs. Operational analyses of EU freight identified that road and rail freight are competing primarily on distances above 500 km. Transport above 500 km has a share of 38% of all freight kilometres and 43% of all freight tkm. Therefore an implementation of this action could have a positive impact on modal shift.

9.7.2 Assessment

Experience and Feasibility

There are no direct experiences with progressive distance pricing in EU. The progressive distance-based charging could meet the EU Eurovignette directive (2006/38/EC), if the income from the charge/tax is used for infrastructure funding purposes (with max. of 25% considered on environmental impact). It is expected that the action will have significant economic impact. For an effective system deployment and operation, the system needs to be cross-country interoperable to allow fair and clear monitoring of freight transport.

Reduction Potential

Table 9.6 Reduction potential – progressive distance pricing

GHG	+
FFS	+
Road fatalities	0
Congestion	+

Pro Arguments:

- Promoting modal shift to alternative freight modes (rail, inland water, . . .)
- Reducing long-distance travel and possible reduce number of road fatalities caused by driver's tiredness
- No need for extensive detection and enforcement system development, this could be applied if the current road user charging schemes are being used as a base of this system.

Contra Arguments:

- Unjustified intervention in market; not in line with present EU policies
- Will require effective and interoperable enforcement system
- Will require legal modification of Eurovignette directive

Conclusion

This action needs to be viewed as an additional or replacement charge / tax to existing distance based charging schemes in Europe. It is expected that in order to apply progressive distance-based charging, all EU countries will need to introduce national road user charging schemes, which are capable of being extended to progressive distance-based charging. The technological and legislative framework needs to be set up for enforcement procedures.

Not recommended due to the complexity of the action and not alliance with existing EU policies.

9.8 Action 7 – Different Pricing with Regards to Type of Freight

Carine Vellay and Martin Volny

9.8.1 Introduction

Different pricing with regards to type of freight aims to promote a modal shift of certain type of goods.

9.8.2 Assessment

Experience and Feasibility

There are no direct experiences related to the implementation of this action. A future implementation will require a modification of the current EU 'Eurovignette' Directive (2006/38/EC). There are no special taxes/charges related to particular freight modes. By privileging one transport mode, the service will become cheaper, but other competitive values as for example time of delivery, reliability, support services etc. are not affected.

The deployment of this action will be complicated as a unified information system is needed, where all type of goods is stored. This system must be easily accessible for enforcement units. The enforcement will need to be done manually by patrol vehicles, which could physically check if the load type of freight is correctly declared and paid for.

Reduction Potential

Table 9.7 Reduction potential – different pricing with regards to type of freight

GHG	+
FFS	+
Road fatalities	0
Congestion	+

Pro Arguments:

- Possible flexible tool for freight type preference
- Reduction of number of trips on road network by promoting alternative modes
- Possible congestion and accident reduction

Contra Arguments:

- Requires good integration monitoring system of goods being transported with effective enforcement
- Difficult to reach agreement (due to interest groups)

Conclusion

This action focuses on shifting certain type of goods on a certain mode. By applying this action, a bigger modal shift could be achieved.

Not recommended due to the expected low acceptance of the action and the complexity of the system enforcement.

9.9 Action 8 – Harmonized Speed Limits

Julia Düh

9.9.1 Introduction

Harmonizing the speed limits between freight and passenger vehicles is one action that is expected to have positive effects on CO_2 emissions, congestion and traffic safety. For long-distance freight transport on road, we focus mainly on high level roads and interurban traffic. Speed Limits vary for vehicle types and among the different countries in Europe. There are varying truck speed limits between 60 km/h and 90 km/h on highways and between 70 km/h and 110 km/h on motorways (IRU).

Harmonizing speed limits result in two areas of interest:

- A speed reduction can have effects on the number of road fatalities, fossil fuel consumption and CO_2 emissions (Federal Highway Administration; OECD, 2005) and
- A reduction of the speed difference between the passenger cars and HGV with regards to the impact on traffic density and flow (EC, 2009).

9.9.2 Assessment

Experience and Feasibility

Since 2007 in France on the A7 in the Rhône area are speed limits introduced for LV and HGV when traffic is too high in order to ease the traffic flow and avoid drivers to «stop and go» on the motorway. Analyses for the motorway A7 show speed limits have very high benefits: it decreases congestion by 25%, road fatalities by 30% and emissions of pollutants (src. ASF).

Company/Market Perspective

The most relevant market players affected by this action are hauliers, vehicle suppliers (of HGV and passenger cars) and passenger car drivers: *hauliers* would prefer if stop-and-go traffic and peaks hours of passenger cars were reduced. *Vehicle suppliers of HGV*: if speed was reduced below 90 km/h, there would be a need to optimize on the lower speed limit. *Vehicle suppliers of passenger cars*: inexpensive cars might become more attractive. Passenger car drivers are against a reduction of speed limits.

Reduction Potential

Table 9.8 Reduction potential – harmonised speed limits

GHG	+
FFS	0
Road fatalities	+++
Congestion	+

Pro Arguments:

- Crash-incidence/crash-severity generally decline when speed limits are reduced
- Summarizing studies: reduction of 1 km/h leads to 3% less number of injury in road fatalities
- Congestion level and emission of pollution may decrease
- Harmonized speed limits can increase the average speed and shorten travel time, free capacity for more vehicles
- Lower average speed may lead to reduced traffic volumes (less vehicles) and mitigate GHG emission.
- Fuel consumption saving

Contra Arguments:

- No EU wide policy on enhanced speed harmonization/reduction
- Few specific HGV studies on changed speed limits (just general for road)
- Free capacities caused by increased average speed may indicate new traffic and may rise CO_2 emission

Conclusion

Reducing and harmonizing speed limits help to save lives and to mitigate emissions in some situations. The efficiency depends on the individual road situation, the traffic density, the speed limit and the average speed. Drivers' education and public work is needed.

Recommended

9.9.3 Recommended Tasks and Milestones

RTD Policy

No new technologies have to be developed, but there is a demand for basic and applied research in the field of harmonizing data collection for safety aspects and simulation projects to optimize traffic flow.

Demonstration projects are the main instrument to gain experience with the action.

Demonstration Projects

- Harmonization of traffic speed with variable message signs for all vehicles with special focus on HGV.
- Safety issues, reliability of traffic flow and impact on CO_2 reduction of passenger and freight transport (interdependencies)

Transport Policy

The current governance regime is that speed limits both for HGV and passenger cars are in the responsibility of the Member States. Directive 2002/85/EC all trucks above 3.5 tonnes have to be equipped with a speed limiter to 90 km/h.

European Transport Policy

- Changed legislation for a maximum 20 km/h speed difference between passenger cars and HGV is one way to harmonize speed limits. This could be one recommendation to Member States.
- Defining minimum quality standards for data collection and analyzing for safety issues for all member states.

National Transport Policy

On national levels, action plans for implementing the harmonization of speed limits on critical roads and national transport demand is needed.

Milestones

By 2020:

- Europe-wide harmonization for data collection and analysis, the demonstration projects are completed and altered legislation should be finalized.

By 2035:

- The concept introduced on critical roads depending on the result of the demonstration projects is implemented by all member states.

9.10 Action 9 – Congestion Charge

David Bonilla, Olaf Meyer-Rühle, and Nihan Akyelken

9.10.1 Introduction

Congestion is caused when transport demand outstrips capacity within the road network. It generally occurs only temporarily at peak hours of light vehicle traffic. Congestion translates into costs for time loss, for environmental damage, and for road fatalities. These costs, also, raise operating costs and the cost per mile of LDFT truck movements. The effect of charging is to reduce travel demand and congestion at peak

periods, and to increase speeds and the total net benefits of moving goods and travel. Recycling revenues of congestion could make the action more acceptable.

9.10.2 Assessment

Experience and Feasibility

Congestion is caused by both light and heavy vehicles. There is no congestion charging outside urban areas in the EU27 Member States. France abandoned its congestion charge scheme. Most congestion is caused by light vehicles rather than by LDFT trucks and policy should avoid singling out HGVs. The action can, however, have a positive impact on our four criteria. The charge should be fiscally neutral.

Company/Market Perspective

Road users would save driving time, and may reduce fuel consumption and emissions, which translate into lower operating costs. A congestion charge should focus on time of day and on place of congestion; for maximum efficiency the charge should be fiscally neutral in the sense that revenues from charges in congested (peak) hours should be redistributed to those who use the roads outside the peaks. The impact of such a charging scheme would be modest for HGVs which operate throughout the day.

Reduction Potential

Table 9.9 Reduction potential – congestion charge

GHG	++
FFS	0
Road fatalities	+
Congestion	+++

Pro Arguments:

- Lower HGV operating costs, driving time savings, reduction of fuel consumption and of emissions

Contra Arguments:

- General congestion charge un-founded
- Charge for LDFT only inadequate, since congestion is largely caused by light vehicle traffic peaks
- High implementation costs
- Faces strong opposition for passenger traffic (mobility restrictions)

Conclusion

Congestion charging for LDFT is a politically controversial action, since most congestion is caused by the passenger car. The Commission's proposal to introduce an around-the-clock congestion charge is unfounded and inadequate to reduce congestion. This charge has to be fiscally neutral. Recycling of revenues strengthens its overall political and social feasibility (Safirova et al., 2003).

As a fiscally neutral action, focused on traffic shift to off-peak periods and applied to all road users in the congested area, it is

Recommended

9.10.3 Recommended Tasks and Milestones

RTD Policy

Like the internalization of external costs, the main technology policy relevant for the action should deal with the high implementation costs of the action. This requires research on improved technologies that may reduce the costs of the action's implementation. The action would require research on real time measurement of traffic flow and real time charging as well as research on the clarification of the definition of external costs and congestion. Additional research is required to identify if/where the action threatens the European competitiveness and regional cohesion.

Since there is no congestion charge outside urban areas in the EU27, a demonstration project in non-urban regions should provide a useful test of the action.

Transport Policy

The action should be applied in EU regions where relevant, i.e. where there is congestion. Although the EC should provide the main framework, the Member States should be allowed to customize pricing and coverage according to their demands.

European Transport Policy

The scheme would be introduced gradually in steps of decades. The main task of the scheme is to develop a rational concept to avoid congestion, i.e. aim at a distribution of traffic that keeps users of infrastructure moving.

National Transport Policy

Congestion charging schemes would be introduced based on a local assessment of the level of congestion. The demonstration projects should be introduced first in the large economies of the EU so as to avoid affecting the economies of new Member States.

Milestones

By 2020:

- The basic field research should be carried out to ease its implementation and for clarifying its definition; and it should be applicable where there is high level of congestion.

By 2035:

- Full coverage of the TEN-T network (without ignoring the possible risks to European competitiveness and regional cohesion).

By 2050:

- The action should be operational in all EU countries where relevant.

9.11 Action 10 – Enforcement of Regulations

Carina Botoft, Søren Saugstrup Nielsen, and Helena Kyster-Hansen

9.11.1 Introduction

In order to ensure that truck drivers and hauliers are following the laws and regulations already implemented within the road freight area, controls are carried out within the Member States. A directive regulates the minimum number of controls, but it seems that when the controls are carried out, a large number of infringements of different areas are found. The controls are also a tool to help all the truck drivers and hauliers that follow the rules and keeps up the good reputation, by given fines to those who do not follow the rules. In this way stricter control is a tool to sort out those who break the laws by driving too fast, drive too many hours, or with too much freight on the trucks, etc. Stricter control could also be of importance when it comes to check whether the hauliers fulfill their obligations to give training in eco-driving to the truck drivers every fifth year. Controls by means of photo cells are another important system to control. The enforcement of regulations in relation to, e.g., the social rules in road transport and safety rules has a important role in ensuring good working conditions for drivers, improving road safety and ensure fair competition and reducing emissions.

9.11.2 Assessment

Experience and Feasibility

In a recent police control in Denmark where trucks and truck drivers were stopped, almost half of them got different kind of fines. A stricter control of trucks, truck drivers

and hauliers could send strong signals to those that do not always follow laws and regulations (or try to twist it), for instance when it comes to respecting the speed limits.

A way of implementing stricter control is to put up more photo-control-systems and connect these with IT systems. Hereby an automatic check can be given upon whether the truck has been driving too fast from one photo-control to another. This is in function in, e.g., Norway and The Netherlands.

Company/Market Perspective

Enforcement of regulations affects hauliers, drivers and industry in general. The way they are enforced has an impact on working conditions for drivers, administrative burdens on both drivers and hauliers, the level of fairness in competition between hauliers and the cost of transport for the industry in general.

Reduction Potential

Table 9.10 Reduction potential – enforcement of regulations

GHG	+
FFS	0
Road fatalities	+++
Congestion	++

Pro Arguments:

- Safer roads are expected if a higher percentage of the truck drivers follow the speed limits and other regulations
- Lower fuel consumption if fewer truck drivers drive too fast
- Possible to make more joined European actions
- Possible to use more photo-control systems

Contra Arguments:

- Expensive to make more control, but probably the costs are low when making cost-benefit analysis (costs for stricter control versus fewer road fatalities and less CO_2 emissions)
- Resistance of “big brother is watching you”

Conclusion

It is highly recommended to make strict controls more frequent and to use more often photo control systems. European coordination of stricter controls and coordination of photo control systems on a broader scale is also

Highly Recommended

9.11.3 Recommended Tasks and Milestones

RTD Policy

In relation to enforcement of regulations, there is a demand for the following research actions:

- Development of new technology that can ease the burden of administration of hauliers and drivers
- Development of automatic control systems, e.g. on rest time, weight and weight distribution
- Develop a training scheme for inspection teams

Demonstration Projects

Make a demonstration project on good practice for enforcement in a number of Member States, to evaluate how it works in different settings.

Transport Policy

The EU decides on the regulations, and it's up to the member states to implement them. This leads to different ways of implementation and enforcement.

European Transport Policy

At the EU level there is a need for co-ordination of the enforcement by clarifying the focus areas of the enforcement, including levels of fines. Furthermore, there is a need to investigate if/how it is possible to simplify regulations.

National Transport Policy

At the national level there is a need for exchange of methods and enforcement in co-ordination with other member states – and the enforcement should focus more on companies that do not comply with regulations.

Milestones

By 2020:

- Enforcement of regulations should be harmonized throughout member states, all drivers and hauliers should comply with all regulations and the EU should make assessment of implementation of all new regulations.

By 2035:

- New technology should relieve administrative burdens for drivers and hauliers, as well as enforcement authorities.

9.12 Action 11 – Investment in Rail Infrastructure

Carine Vellay, Martin Volny, and Andrew Winder

9.12.1 Introduction

Most railways in Europe are shared between passengers and freight transport. In most countries, passenger trains are prioritized on the network and slots are allocated to freight once passenger schedules are defined. Investment in new railway dedicated to freight leads to more performance for rail transport and offers a competitive alternative to road freight transport. Development of railways dedicated to passengers (high speed lanes) can also help to free slots for freight transport on existing railways.

Providing rail corridors that are mainly or completely dedicated to freight can enable rail to become more competitive against other freight modes (especially road transport) and provide a higher quality service, while minimizing conflicts with passenger rail transport. This would address the current barrier to modal shift to rail posed by railway infrastructure capacity constraints.

9.12.2 Assessment

Experience and Feasibility

There is only one existing freight dedicated railway in Europe: the Betuweroute in the Netherlands.

Generally, financing and funding is the main difficulty for building new railways, both freight and passenger ones. Public–private partnerships offer new financial schemes for infrastructure projects with both public and private funding (building, management . . .).

Company/Market Perspective

The main actors could include governments, regions, national rail infrastructure operators, construction companies, financing institutions and other private operators (e.g. in PPPs).

Reduction Potential

Table 9.11 Reduction potential – investment in new railway lines

GHG	++
FFS	+
Road fatalities	+
Congestion	+

Pro Arguments:

- Improves the competitiveness and quality of rail transport supply (fewer delays, reduced travel time. . .)
- Helps to improve intermodality along the corridors and decreases waiting time at borders
- New freight lines would create cooperation and allow to apprehend the European rail network as a whole
- In the long term, creation of new railway lines and a good management will allow the extension of the rail connections with neighbouring countries outside the EU

Contra Arguments:

- Important financial means needed: costs of extending the network
- Improvement and cooperation in network management between countries, between railways managers
- Technical issues have to be taken into account in the construction of the new lines of freight (interoperability, ERTMS, etc. . .)

Conclusion

Investment in new railway lines is a highly recommended action, but it has to be anticipated and developed over a long period of time due to its various constraints (high cost, heavy investment, a higher number of partners, a cost-benefit analysis is required in advance of the implementation of the action, etc. . .).

Highly Recommended

9.12.3 Recommended Tasks and Milestones

RTD Policy

- New technologies for traffic monitoring and control to increase and optimize railway operation and capacity

- Review identified congested railway hubs in Europe and integrate them into unify list with prioritized investment in bypasses of the network bottlenecks;
- Automated goods handling, monitoring of the goods, optimize hub operations, etc.

Demonstration Projects

Prioritize locations of bottlenecks on the EU strategic network and perform feasibility study focused on tackling the line, consolidation centres, and junctions' capacity problems.

And Identify strategic long-distance rail freight corridors and develop framework for cooperation and integration of these corridors.

Transport Policy

The development of the TEN-Rail is a key tenet of EU transport policy. Combined usage (passenger/freight) and dedicated freight lines are supported by EC Directive COM (2008) 852, which focuses on priority rail freight corridors. Investment is essentially at national level, with EU funding for projects of regional or trans-European importance (ERDF /TEN-T funding).

European Transport Policy

EU policy supports the construction of new lines and improvements to existing lines to achieve high-quality pan European rail networks for passenger and freight traffic, with these conflicting types of train operation managed or separated to the maximum extent. Development of high-speed passenger rail should not relegate freight to secondary importance; rather it could help release capacity on classic railway lines for more freight use.

National Transport Policy

Focus on deployment of national/regional railway corridors/lines for both combined usage (passenger/freight) and freight only with effective cross-border connections and links to ports.

Milestones

By 2012 integrate current railway infrastructure needs (already identified) into document covering the TEN-Rail network and develop appropriate financing models for new rail infrastructure, including research on best practice for business models. By 2035 approve and commence construction on key railway infrastructure (lines, junctions, freight yards, etc) with secure finance packages. By 2050 an integrated TEN for rail freight will exist, with major bottlenecks removed.

9.13 Action 12 – Freight Prioritization

Arne Böhmann and Frank Panse

9.13.1 Introduction

Freight transport corridors consist of lines that combine passenger and freight transport with enough capacity to accommodate the whole of the demand for freight transport services.

9.13.2 Assessment

Experience and Feasibility

The European Commission wants to determine European rail networks which consist of transnational freight traffic corridors. These corridors are going to be reserved for prior freight traffic. About 12500 km of railway tracks have to be built and 12300 km modernized in order to cover all networks. A proposal of the European Commission states that 3 years after taking effect each Member State has to set up at least one corridor. If transport volumes exceed 30 or 70 bn tkm at least two or three corridors have to be set up. Further decisions on the proposal are to be expected by the end of October 2009.

Company/Market Perspective

The most relevant market players affected by this action are the rail freight industries and the rail passenger transport sector:

- Rail-cargo companies would prefer if priorities on corridors were shifted to improve competitiveness in the transport sector
- Rail passenger transport would be less attractive as a mode to travel if no new logistical concepts for both passenger and freight transport are introduced
- Infrastructure managers are able to regulate track distribution by track access fees

Reduction Potential

Table 9.12 Reduction potential – freight prioritization

GHG	+++
FFS	++
Road fatalities	0
Congestion	++

Pro Arguments:

- Decreasing costs of transportation
- Creating a competitive mode of transportation in terms of costs and punctuality
- Reduction of environmental costs
- Faster handling of goods
- Decreasing standing times at the borders
- Improvement of intermodality along the corridors

Contra Arguments:

- Reduces availability for passenger transport
- Increasing delays in passenger transport can be expected
- Train path compensations could increase and as a result increase the price for passenger transportation
- Passengers might decide to select another mode of transportation as their first choice
- Increasing costs of congestion due to decreasing numbers of passengers in the railway sector
- Investments in passing loops
- Noise pollution
- Costs of upgrading and extending the infrastructure

Conclusion

The setting up of freight transport corridors is an important step toward a competitive freight transport sector. It secures punctuality and decreases costs of transportation. Freight transport corridors have to compete with the passenger transport sector, which in most cases has priority and would have to deal with increasing delays and availability. A cost-benefit analysis is required in advance of the implementation of the action. The prioritization of freight transport on railway lines is

Recommended

9.13.3 Recommended Tasks and Milestones

RTD Policy

Demand for research concerning new logistical concepts in the freight and passenger transport sector.

- Cost-benefit analysis (Integrated Impact Assessment)
- Social studies (influence on availability of public transport)
- New logistical concepts and pricing structures

Demonstration Projects

- Impact on competitiveness of the rail freight transport sector
- Impact on CO_2 reduction of the freight transport sector
- Demonstration of concept on a secondary line for freight and passengers

Transport Policy

The current governance regime is that passenger transport has priority on European corridors. The European Commission wants to determine European rail networks which consist of transnational freight traffic corridors. Further decisions on the proposal are expected to follow by March 2010.

European Transport Policy

Recommendation for the setting up of priority rail freight corridors in order to increase the market share of freight transport. KOM(2008)852

National Transport Policy

Balancing of rail track availability for the passenger and transport sector.

Milestones

By 2020:

- Demonstration projects finalized until 2020
- EC-Recommendations until 2020

By 2030:

- Increase of freight train speed limits to 120 km/h

By 2050:

- Increase of freight train speed limits to 160 km/h

9.14 Action 13 – Funding for ERTMS / ECTS

Kamil Krusina and Vit Malinovský

9.14.1 Introduction

ERTMS is rapidly becoming the major global standard not just in Europe but around the globe, according to statistics on ERTMS deployment by UNIFE, the European rail industry. As a first step the upgrade of the TEN-T network to Level 2 is recommended.

ERTMS consists of two basic components:

ETCS, the European Train Control System, is an automatic train protection system (ATP) to replace the existing national ATP-systems;

GSM-R, a radio system for providing voice and data communication between the track and the train, based on standard GSM using frequencies specifically reserved for rail application with certain specific and advanced functions.

ERTMS aims at replacing the different national train control and command systems in Europe. The deployment of ERTMS will enable the creation of a seamless European railway system and increase European railway's competitiveness.

9.14.2 Assessment

Experience and Feasibility

More than 2200 km tracks in the EU are operated with the support of the ERTMS. Further thousands kilometres tracks are under construction across the whole EU. ERTMS is already under commercial service in some countries outside EU – South Korea 760 km and Taiwan 1200 km. Other countries (Saudi Arabia, Mexico, India, Algeria, China) are in construction phase.

Company/Market Perspective

The suppliers for ETCS are the 6 UNISIG companies: Alstom Transport, Ansaldo STS, Bombardier Transportation, Invensys Rail Group, Siemens Mobility and Thales. On the customer side are the railways companies and the railway infrastructure operators both international and regional ones.

Reduction Potential

Table 9.13 Reduction potential – funding for ERTMS/ETCS

GHG	++
FFS	+
Road fatalities	+
Congestion	+

Pro Arguments:

- Technical interoperability of international rail transport
- High level of safety
- Increase of capacity, due to decrease of headway between trains and increase of velocity, due to decrease of time loss on the borders on European railway tracks

- Decrease of control and communication systems on train's cockpit, and following decrease of care, maintenance and crew training costs
- Standardized product, applicable outside EU

Contra Arguments:

- Non-uniform operation procedures in Europe complicate the introduction of ETCS
- During the phase of introduction, the old and new system have to run simultaneously which leads to increasing costs
- Infrastructure operators with already existing efficient rail traffic guidance systems profit only marginally
- GSM-R capacities are not efficient in areas of railroad yards and railway junctions

Conclusion

ERTMS/ETCS seems to be very prospective technology, further implementation is

Highly Recommended

9.14.3 Recommended Tasks and Milestones

RTD Policy

Demand for the following actions:

- New technologies and logistical concepts for ERTMS (control and signaling systems compatible at multimodal transportation, effective in logistical centers and for MMT coordination generally)
- Roadmaps and new technologies
- New technologies using the capabilities of ERTMS

Transport Policy

ERTMS has now become the accepted global ATP standard and is trusted by the railways worldwide, thanks to the considerable advantages it brings in terms of capacity and multi-supplier capabilities. ERTMS introduction should be funded by EC to some agreed extend.

European Transport Policy

The European Commission supports the implementation of ERTMS systems and services across all transport modes aiming at transport safety and efficiency increase, particularly on the trans-European transport network (TEN-T). EC should introduce studies emphasizing ERTMS expediencies as well return of investments to ERTMS.

National Transport Policy

The EU countries consider this issue very consistently; it provides support to European-wide efforts in this area. The interest in the transport telematics development and the support to such technologies is being manifested not only by the authorities but also by regional and municipal authorities. Member states should cooperate more on international ERTMS standardization, ensuring transport effectiveness and interoperability for prospective use.

Milestones

By 2020:

- ERTMS implementation at main lines and equipment (about 4000 locomotives)

By 2035:

- Main lines and secondary lines equipped with ERTMS (equipment and tracks)

By 2050:

- Full coverage of ERTMS (equipment and tracks)

9.15 Action 14 – Electrification of Rail Corridors

Arne Böhmann and Frank Panse

9.15.1 Introduction

Electrification provides a variety of advantages as lower fuel costs, faster acceleration, lower capital and maintenance costs, reduced air pollution and locomotives with substantially longer service lives. So far about 50% of the EU27 lines are electrified.

9.15.2 Assessment

Experience and Feasibility

Until the year 2050 the rate of electrification can probably be expected to rise to a level 75% in line with the current developments. About 80% of all rail freight transport is likely to be transported on electrified rail tracks.

Company/Market Perspective

The most relevant market player affected by this action is the rail freight industry:

- *Rail cargo companies* would achieve a higher level of fuel and cost effectiveness
- *Rail operators* would concentrate on e-transport

Reduction Potential

Table 9.14 Reduction potential – electrification of rail corridors

GHG	+++
FFS	++
Road fatalities	0
Congestion	+

Pro Arguments

- 35% cheaper to operate than diesels
- Electricity is cheaper than fuel
- Trains are lighter and do less damage to the tracks
- Electric locomotives are cheaper to buy than diesels
- Electric trains emit less carbon
- Regenerative braking enables trains to reuse energy that would have been lost while braking
- Electric trains are quieter than diesel trains
- Improved interoperability

Contra Arguments:

- Costs for setting up the infrastructure
- Maintenance of the infrastructure

Conclusion

About 50% of the EU27 lines are electrified and more are to be electrified in the future. Electrification has the main impacts on the environment as it leads to reduced fossil fuel consumptions and GHG emissions.

However infrastructure investments are needed to improve the level of electrification. The European wide electrification of railway lines is

Highly Recommended

9.15.3 Recommended Tasks and Milestones

RTD Policy

Research hast to be done concerning uniform electrification systems and/or multisystem locomotives.

- Track access charges for diesel and e-locomotives
- Uniform electrification systems
- Cost-benefit analysis
- Implementation of stricter CO_2 restrictions
- Multisystem locomotives

Demonstration Projects

- Impact on CO_2 reduction of passenger and freight transport
- Impact on operational costs
- Multisystem locomotives

Transport Policy

The current governance intention is to foster alternatives to fossil fuels in order to decrease CO_2 emissions.

European Transport Policy

The electrification of all European rail tracks is recommended. The European Commission should enforce the upgrade of railway tracks.

National Transport Policy

Introduction of change processes for unification of electrical systems, infrastructural investments and upgrades for electrification.

Milestones

By 2050:

- A full coverage of electrification on European main corridors should be achieved

9.16 Actions 15 – Longer Trains

Arne Böhmann and Frank Panse

9.16.1 Introduction

An action to increase the capacities of rail freight transportation could be the usage of longer trains. However train length restrictions differ in the European countries.

9.16.2 Assessment

Experience and Feasibility

For example the restrictions on the corridor from Spain to Hungary are as follows: 600 m on the Spanish part, 750 m on the French part, 625 m on the Italian part, 600 m on the Slovenian part and 750 m on the Hungarian part. For this corridor, infrastructural actions would make sense to at least secure uniform restrictions of 750 m. Train lengths of up to 1500 m are imaginable on some corridors in the future. The first step toward upgrading of train lengths therefore is to identify all potential corridors. Longer trains are already common practice on a few routes. In Denmark trains with a length of 835 m are allowed.

Company/Market Perspective

The most relevant market player affected by this action is the rail freight industry:

- *Rail cargo companies* would prefer if train length restrictions were uniform and extended
- *Infrastructure managers* would have to create new concepts
- *Industries*

Reduction Potential

Table 9.15 Reduction potential – longer trains

GHG	++
FFS	++
Road fatalities	0
Congestion	+

Pro Arguments:

- Increase of capacity
- Less trains needed to transport the same amount of goods
- Improved interoperability due to uniform restrictions

- Reduction of operational costs, personnel costs and maintenance costs
- Lower fuel consumption per tkm

Contra Arguments:

- More time needed to load and unload the wagons at trans-shipment points
- Possibly decreasing velocity
- Most railway tracks are not adapted to carry longer trains (infrastructural deficits)
- Passing loops that are too short for longer trains
- Trans-shipment stations are not efficient for longer trains
- High investments are required

Conclusion

The implementation of longer trains in Central Europe still is in the early stages of development. However if implemented it leads to higher capacities, reduced fuel consumptions and reduced managing costs. It is clear that the action consumes large infrastructure and train upgrade investments. A first step should be to at least create uniform European wide train lengths to insure interoperability. A cost-benefit analysis is required in advance of the implementation of the action. The FERRMED ASBL is promoting the concept of a high capacity rail freight axis Scandinavia-Rhine-Rhone-Western Mediterranean with the implementation of so called FERRMED Standards, essentially 1500 m trains with up to 25 tonnes axle load on a 8000+ km main network with almost 14000 km feeder lines.

The implementation of longer trains and European wide uniform restrictions is

Recommended

9.16.3 Recommended Tasks and Milestones

RTD Policy

Research has to be done concerning infrastructural deficits, bottlenecks and technical obstacles that need to be resolved.

- Track bed
- Trans-shipment stations
- Cost-benefit analysis (Integrated Impact Assessment)
- Logistical concept
- New logistical concepts
- Adoption of infrastructure

Demonstration Projects

- Impact on freight train capacities on main line
- Impact on energy consumption
- Running tests with longer trains on current rail freight corridors

Transport Policy

The current status is that train length restrictions range from 600m to 750m in most European countries.

European Transport Policy

The setting up of uniform train length restrictions on major corridors in Europe is recommended.

National Transport Policy

Infrastructural upgrades and investments for the railway networks.

Milestones

By 2020:

- Demonstration projects finalized
- Implementation of trains of 1000m

By 2030:

- Implementation of trains of 1500m

9.17 Action 16 - Heavier Trains

Arne Böhmann and Frank Panse

9.17.1 Introduction

The current common axle load that applies to most of the corridors investigated is 22.5 tonnes per axle (or more in some parts). Most of the rest is on 20 tonnes per axle. The implementation could increase the capacities of rail freight transportation.

9.17.2 Assessment

The current common axle load that applies to most of the corridors investigated is 22.5 tonnes per axle (or more in some parts). Most of the rest is on 20 tonnes per axle.

Experience and Feasibility

Considering the current product mixes observed and considering the expected market trends towards a faster growth of light freight, upgrading the infrastructure on corridors to higher axle load values or simply harmonizing axle loads to 22.5 does not seem absolutely crucial. In cases where infrastructure works are otherwise planned, it is however recommended that the target value should at least be 22.5 tonnes. In the long term, higher axle loads (e.g. 25 tonnes) may also be considered.

Heavier trains are already in use in a few cases. In Germany for example heavy block trains with a gross weight of 6000 tonnes are operated between Hamburg and Salzgitter to transport ore to the steel mill in Salzgitter. These trains have lengths of about 600m and axle loads of 25 tonnes.

Company/Market Perspective

The most relevant market players affected by this action are the rail cargo companies:

- Rail cargo companies would prefer if train weight restrictions were uniform and extended
- Infrastructure managers would have to create new concepts
- Industries

Reduction Potential

Table 9.16 Reduction potential – heavier trains

GHG	++
FFS	++
Road fatalities	0
Congestion	+

Pro Arguments:

- Increase of capacity
- Less trains needed to transport the same amount of goods
- Improved interoperability due to uniform restrictions

- Reduction of operational costs, personnel costs and maintenance costs
- Lower fuel consumption per tkm

Contra Arguments:

- More time needed to load and unload the wagons at trans-shipment points
- Possibly decreasing velocity
- Most railway tracks are not adapted to carry heavier trains (infrastructural deficits)
- Longer braking distances
- Loads depend on gradients

Conclusion

The action consumes large infrastructure and train upgrade investments. A first step should be to at least create uniform European wide weight restrictions to insure interoperability. A cost-benefit analysis is required in advance of the implementation of the action.

The implementation of heavier trains and European wide uniform restrictions is **recommended.**

9.17.3 Recommended Tasks and Milestones

RTD Policy

Research has to be done concerning infrastructural deficits, bottlenecks and technical obstacles that need to be resolved.

- Track bed
- Coupling systems
- Wheel–track interaction
- Cost-benefit analysis (Integrated Impact Assessment)
- Logistical concept
- New rolling stock
- New logistical concepts
- Adaptation of infrastructure

Demonstration Projects:

- Impact on freight train capacities
- Impact on energy consumption
- Running tests with heavier trains on current rail freight corridors

Transport Policy

The current status is that train weight restrictions range from 20t to 22.5t in the European countries.

European Transport Policy

The setting up of uniform train weight restrictions on major corridors in Europe is recommended.

National Transport policy

Infrastructural upgrades and investments for the railway networks.

Milestones

By 2020:

- Demonstration Projects finalized
- Recommendations
- Implementation of trains with 25t axle load
- Increase of tonnes per wagon meter to 8 tonnes

By 2035:

- Implementation of trains with 30t axle load

9.18 Action 17 – Investments in IWT Infrastructure

Ronald Jorna and Hans Zuiver

9.18.1 Introduction

The quality of the EU inland waterway network is highly recognized, as well as the fact that IWT is more environmentally friendly than road transport. The share of IWT is nevertheless decreasing over time. To strengthen the competitive position of IWT and to facilitate its integration into intermodal logistics chains, investments in IWT infrastructure have to be made.

Capacity of the IWT network is hampered by bottlenecks. Lack of sufficient investments have led to a reduction of preventive maintenance, unexpected draught restrictions, temporary closure of locks, etc. This results in unreliable services, reduced safety and higher costs.

9.18.2 Assessment

Experience and Feasibility

Since IWT still has capacity that is not fully exploited, its links to other transport systems have to be improved. Favourable conditions are created through improvements in the infrastructure, ITS (including RIS) and implementation of the European action plan on the Promotion of Inland Waterway Transport (NAIADES).

The TEN-T priority axes include two inland waterway connections (nr. 18 and 30). Although the main attention is on these two, 3 other cases are under investigation. This includes the Elbe and Oder rivers in Czech Republic, the Po river basin in Italy and the Terneuzen bottleneck in the Netherlands linking the two priority axes.

Company/Market Perspective

The most relevant market players affected are vessel owners and logistic companies. After all, solving bottlenecks enables improved use of the IWT network. Stable vessel utilization rates lead to improved attractiveness of the IWT sector.

Reduction Potential

Table 9.17 Reduction potential – investments in IWT infrastructure

GHG	+
FFS	0
Road fatalities	+
Congestion	++

Pro Arguments:

- The external costs of IWT are 7 times lower per tkm than those of road transport
- IWT is safe, in particular for dangerous goods
- It makes IWT less sensitive to extreme weather (water too high, too low), thus more competitive

Contra Arguments:

- Only 12 out of 27 Member States have an interconnected waterway network
- Due to low speed IWT is not suitable for every type for cargo

Conclusion

IWT has major assets relevant for the transport sector; compared to other modes it is effective, energy-efficient and safe. Tackling of bottlenecks, multi-modal links and the implementation of RIS improve the competitive position, resulting in a growth of 1% per year until 2030. However, due to higher percentages in other modes, the modal share is foreseen to decrease from 11.4% in 2005 to 9.6% in 2030 (SSS not included).

Recommended

9.18.3 Recommended Tasks and Milestones

RTD Policy

As this action does not depend on the development of new technologies, there is neither need for basic or applied research, nor for demonstration projects.

Transport Policy

In the last decades there has been significant underinvestment in the IWT network. Between 1995 and 2005, the EU invested some €800 billion in infrastructure, of which only 1% was allocated to IWT. IWT freight volume (tonnes) has nevertheless managed to grow by 14.5%, more than any other transport modality.

This underinvestment also shows at national scale. Smaller waterways (classes I–III) are more and more neglected and loose in importance, although they can serve for feeder services from and to ports ("hubs"). This trend will continue unless additional policy initiatives are developed.

European Transport Policy

- Integral investment approach for all modes, taking into account financial, spatial and environmental issues.
- Development plan for the improvement and maintenance of inland waterways and transhipment facilities.
- Integrated network plan that goes beyond the TEN-T axes and takes into account smaller waterways.

National Transport Policy

- National funding schemes for improvement and maintenance of inland waterways.
- Development of port and transhipment facilities.

- Implementation of RIS and future services in line with RIS Directive.
- Assessing the possibilities of privatisation of canals, including maintenance.

Milestones

By 2020 the following should be achieved

- Completion on the 2 IWT TEN-T axes
- Full-scale implementation of RIS
- IWT infrastructure development plan
- Integral long term Infra funding scheme

9.19 Action 18 – Develop New Technologies in IWW

Julia Düh and Lucas Weiss

9.19.1 Introduction

Inland waterway is characterized by high efficiency and low energy consumption per tkm. Its energy consumption per tkm of transported goods is approximately 17% of that of road transport and 50% of rail transport. Its noise and gaseous emissions are modest. The emissions of restricted pollutants like NOx, PM, CO and HC from the waterway transport are steadily decreasing, because of changing emission standards.

New technologies are needed to fasten the changing of containers between barges, trucks, trains. New technologies will support efficiency, ecological and safety aspects within the whole IWW and SSS system including vessels, engines, infrastructure and cargo handling (Telias et al., 2009).

9.19.2 Assessment

Experience and Feasibility

For inland waterway and short-sea shipping, it is very essential for Europe to develop innovative and new ideas and technologies for the logistics port structures, lock management and the vessel fleets, to handle the constant growing flow of goods. Some of these ideas and technologies are x-gate vessel tracking systems, the ARROW program, sky sails, and port feeder barge, fuel cells for low emission ships (Fellow-SHIP), Small Waterplane Area Twin Hull (SWATH) and Powered catamarans. (Böhmann et al., 2009)

The Commission aims to create favourable conditions for the further development of the sector through improvements in the infrastructure, intelligent transport systems

(including RIS – River Information Services) and implementation of the European action plan on the Promotion of Inland Waterway Transport (NAIADES) (EC - NAIADES, 2006).

Company/Market Perspective

The most relevant market players are logistic companies, cargo and vessel/barges owner and infrastructure manager.

Reduction Potential

Table 9.18 Reduction potential – develop new technologies in IWW

GHG	++
FFS	+
Road fatalities	+
Congestion	+

Pro Arguments:

- More knowledge about the positioning of other barges
- Fewer fuel consumption because of better planned trips with continuous speed
- Reduction of GHG by implementing new fuel cells
- Reducing time for port stops/stays because of easy cargo handling
- High potential for modal shift of freight

Contra Arguments:

- Long time horizon for changing activities because of long life cycle of barges and machines
- High investment costs for new propulsion system in the vessels

Conclusion

New technologies which support efficiency, ecological aspects and safety are applicable for the whole IWW and SSS system, for vessels, engines, infrastructure and cargo handling.

But due to the very long life cycle of barges, vessel and infrastructure new technologies are not diffused within next 20–25 years, but some better techniques can also be applied to existing vessels.

Recommended

9.19.3 Recommended Tasks and Milestones

RTD Policy

Barges, vessels and infrastructure have a very long life cycle. Changes to new technologies with the aim to be more environmental friendly require a lot of time, research and investments.
Research has to concentrate on:

- Supporting a diverse set of alternative fuels
- Concept for clean engines and environmental friendly design

Demonstration Projects

- Refitting elements of barges and machines for more environment-friendly engines
- R&D for quicker transfer of containers

Transport Policy

Inland waterway transport plays currently an important role in Germany and the Benelux countries. Related to the GHG emissions of other modes of transport inland waterways are of minor importance in the next decades.

European Transport Policy

- Implementing and improving green corridors: drive on steady speed, alternative fuels
- Taxing fuel/differentiating

National Transport Policy

- National funding for IWT implementation of new applications
- Implementation of RIS and future services in line with the EU's RIS Directive.

Milestones

By 2020 the following should be achieved:

- 50% Subsidizing engines (barges, vessels) replacing old engines for new energy-efficient, emission reduction devices
- Implementing alternative fuels (clean, ultra-low sulphur)

By 2050:

- 80% of the barges are replaced by vessels and barges with environmental friendly engines and fuels.

9.20 Action 19 – Investments in Maritime Port Infrastructure

Ronald Jorna and Hans Zuiver

9.20.1 Introduction

Today most goods from the Far East arrive in the ports of Northern Europe and are then transported to their final destination across the EU. In the medium- or long-run developments of port infrastructure, hinterland connections and transport networks could bring around a shift of goods flows from the Northern range to the Mediterranean Area.

In 2018 maritime freight volumes are expected to have grown from 3.7 bn tonnes (2006) to 5.3 bn tonnes. In 10 years time EU ports and the shipping industry thus have to be able to handle, at least 1.5 billion tonnes more than today. Investments in port infrastructure are needed to improve efficiency and productivity rates.

9.20.2 Assessment

Experience and Feasibility

The European ports policy stressed the possibility to explore alternative transport routes as a means to achieve a more intensive use of existing ports – some of which are operating under capacity levels. This would lead to a more rational distribution of traffic across the EC, resulting in less tkm and less negative effects linked to freight transport (congestion, road fatalities, emissions etc.). It is however expected that countries in Northern Europe will not support actions stimulating (competitive) ports in other countries, unless they act as feeder for the main ports in the EU. It is expected that countries in Europe will not support actions stimulating (competitive) ports in other countries. Currently, ports are expanding capacity in order to cope with the expected increasing cargo-handling demand after the world wide economic crisis (e.g. Maasvlakte II in Rotterdam).

Company/Market Perspective

Ports are a direct and indirect source of more than half a million jobs employees and ensure dynamism and development of regions. Investing in port infrastructure influences shipping and logistic services, including port services, cargo handling, hinterland transport, shipbuilding and other maritime related industries.

Reduction Potential

Table 9.19 Reduction potential – investment in maritime port infrastructure

GHG	++
FFS	0
Road fatalities	+
Congestion	++

Pro Arguments:

- Short-sea shipping carries 40% of intra-European freight (tonne-km)
- In 10 years ports have to handle 1.5 billion tonnes more than today
- Most ports face bottlenecks and are operating under capacity levels
- SSS requires higher port efficiency and good hinterland accessibility

Contra Arguments:

- Individual countries stimulate their own ports because of the economic importance, there is no common interest
- Container vessels prefer to have 1 or 2 calls in EU ports. These market forces should not be forgotten when investing in smaller ports

Conclusion

However, looking ahead, maritime transport is expected to grow again. This means that the maritime infrastructure, including ports and its links to the hinterland has to be improved. Investments in port facilities also have links with other actions including the motorways of the sea and the European maritime transport space without barriers.

Recommended

(Decentralization of ports is not recommended – this is market-driven).

9.20.3 Recommended Tasks and Milestones

RTD Policy

Since investments do not depend on the development of new technologies, there is no need for research or demonstration projects. There is need for actions to make ports more efficient, safer and cleaner.

Transport Policy

The EC has described strategic goals and recommendations for its maritime policy until 2018. Future actions should focus on increasing port efficiency and productivity rates, in terms of output or movements per hectare and through improvement of hinterland connections (road, rail and inland waterways).

European Transport Policy

- Adopt transparent guidelines on State aid to ports to promote efficiency and support greener shipping efforts/technological innovation.
- Adopt guidelines on fee structures in order to simulate SSS activities (instead of discouragement).
- Support smaller ports, which act as feeders for the main ports, in order to minimize land transport.

National Transport Policy

- Harmonize national investment programs with EU port policy.
- National single window concept, dealing with information to and from the national (port) authorities.

Milestones

By 2020 the following should be achieved:

- Expansion of short-sea shipping and motorways of the sea activities (as part of the TEN-T network)
- Full implementation of maritime space without barriers.
- Long-term strategic goals and recommendations for the maritime transport policy (beyond 2018).

9.21 Action 20 – Training for Eco-driving

Carina Botoft, Søren Saugstrup Nielsen, and Helena Kyster-Hansen

9.21.1 Introduction

The driving style of a truck driver has major impact on the amount of fuel that is used to drive a truck. Several projects on eco-driving have shown that training and education of the truck drivers concerning eco-driving gives reductions in the total diesel consumption for the truck.

From September 2009 all new driving licenses for truck drivers will have elements of eco-driving. All truck drivers with driving licenses taken before September 2009 have to take part in follow up courses, where eco-driving is one of the subjects.

9.21.2 Assessment

Experience and Feasibility

Eco-driving has significant potential to deliver CO_2 reductions quickly and cost-effectively; there appears to be savings potential of 10% of surface transport sector emissions. Immediately after eco-driving training, average fuel economy improvements of between 5–15% have been recorded, for example in the Austrian national program for commercial vehicles, and data on the UK Freight Best Practice program confirms a potential of 10% fuel savings from eco-driving.

The long-term impact seems to be around 2–3% fuel savings with no follow-up incentives program. With implementation of eco-driving courses every fifth year for all truck drivers (which started up September 2009) and with implementation of incentive schemes, savings around 7–8% in fuel reductions should be possible.

Company/Market Perspective

Eco-driving is potentially interesting for all commercial partners. It can reduce the cost of transport, by reducing fuel consumption and maintenance costs. It can also reduce GHG emissions, local air pollutants, noise nuisance and the drivers' stress level.

Reduction Potential

Table 9.20 Reduction potential – training for eco-driving

GHG	++
FFS	0
Road fatalities	++
Congestion	+

Pro Arguments:

- Projects confirm a potential of 10% fuel savings from eco-driving on short term
- With follow up incentive program 7–8% fuel savings should be possible in long term
- Eco-driving also reduces vehicle maintenance costs, stress, noise nuisance and local air pollutants
- Eco-driving improves traffic safety, comfort

Contra Arguments:

- Divers' travel time increases (But this loss of efficiency is marginal in relation to the potential fuel savings when performing eco-driving)

Conclusion

It is highly recommended to support different strategies to maintain the habit of eco-driving once training is over. IT applications in the trucks supporting eco-driving and incentive schemes for hauliers and truck drivers should be available and easy to apply all over Europe.

Highly Recommended

9.21.3 Recommended Tasks and Milestones

RTD Policy

There is a need for the following research actions:

- Development of technology for improving eco-driving, e.g. eco-meters
- Eco-driving should be combined with the actions of "defensive driving" (driving to save lives, time and money, in spite of the conditions around you and the actions of others).
- Collect evidence on eco-driving and defensive driving, promote and provide information on the positive effects to stakeholders, including good practice guide.
- Investigate how to transfer eco-driving to rail and sea transport

Demonstration Projects

There are already some demonstration projects on eco-driving in different member states, but there is a need for demonstration projects in combination with defensive driving.

Transport Policy

The EU driver education, with a module on eco-driving should be implemented from 10/10/2009 for all truck drivers in Europe. From here on all new driving licenses will have a module on eco-driving and all truck drivers, both new and experienced, are required to take part in follow up courses every fifth year.

European Transport Policy

The directive on driver education has been implemented differently in the member states and this affects the competition. There is a need for co-ordination of the regulations by the EU.

National Transport Policy

The member states should implement the directive and ensure the enforcement thereof.

Milestones

By 2020:

- A directive combining eco-driving and defensive should be implemented, together with EU-wide harmonization of implementation.

By 2035:

- All other modes should have an implemented EU directive on training in eco-driving

In a longer perspective the effect of eco-driving is small since it only creates a “one off saving” that demands continuous training to keep and further savings largely depends on development of new technology in other areas.

9.22 Action 21 – Automated Platooning

Ronald Jorna and Hans Zuiver

9.22.1 Introduction

Automated platooning refers to the situation in which trucks are coupled electronically and exchange information, but still need drivers that can intervene if needed. At this moment driving behind another vehicle, at a distance that does not guarantee that stopping to avoid a collision is possible, is called tailgating. This is illegal, currently preventing platooning of vehicles. The time in which fully automated “hands-off” trucks will be running on our highways is still far from now; nevertheless automatic guidance (platooning) is a key objective if we want to improve safety and efficiency of road transport. Within this project the term platooning refers to the situation in which trucks are coupled electronically and exchange information, but still need drivers that can intervene when needed.

9.22.2 Assessment

Experience and Feasibility

Different EU funded projects have studied the potential of vehicle-to-vehicle communication, showing that platooning is technically feasible. The system allows vehicles to drive closer to one another, increasing the potential of highways and resulting in less drag for the followers (resulting in 10% to 20% less fuel consumption). It also provides the vehicles and drivers with critical and real-time information well in advance as compared to human natural senses or existing electronic tools, hereby reducing the chance on road fatalities. However, to be really effective all vehicles should be with V2VC systems.

Company/Market Perspective

The most relevant market players affected by this action are hauliers, vehicle suppliers and private car drivers:

- Hauliers will benefit from improved safety and reduced costs. New driving time and rest periods may improve efficiency.
- Private car drivers will experience the comfort of hands-off driving during inter-urban travel.
- For vehicle suppliers it is uncertain whether the costs of the technology will be covered.

Reduction Potential

Table 9.21 Reduction potential – automated platooning

GHG	+
FFS	0
Road fatalities	+
Congestion	+

Pro Arguments:

- Improvement of traffic flows
- Increased safety due to automated guidance and reduced workload
- Lower fuel consumption (10% to 20%) for the followers
- Reduced environmental impacts
- More efficient use of infrastructure

Contra Arguments:

- Conventional traffic reduces the potential of the system
- There are technical issues and legal hindrances
- System only provides benefits for followers, not for the leader
- Trucks (and cars) need to be equipped with V2VC systems
- Acceptance by truck drivers is unknown
- Bridges, tunnels etc. may prevent the system to be used optimally – thus reducing the benefits

Conclusion

Although the technology has been demonstrated in closed environments, it has not yet been implemented in real-life. The system is not designed to coexist with conventional vehicle traffic on existing highways. Finally it should be stated that there is not enough data available regarding costs and benefits to describe the potential on the four areas under investigation within the FREIGHTVISION project.

Recommended

9.22.3 Recommended Tasks and Milestones

RTD Policy

Although the technology required has been demonstrated in closed environments, still much needs to be done.

- Develop and integrate technologies (ADAS, collision warning, V2V and V2I communication, location based services etc.) in a prototype service.
- Develop strategies on how automated guided trucks (and private vehicles) can operate on EU highways without changing road infrastructure.

Demonstration Projects

- Demonstrate in real-life the operational aspects of platooning and the influence of platooning on congestion, safety, fuel efficiency and CO_2 emissions and assess the need for dedicated infrastructure.

Transport Policy

European Transport Policy

- Set standards for the platooning communication system, to be used across the EU by all vehicle suppliers.

- Update Regulation EC/561/2006, setting new rules for driving times and rest periods regarding platooning vehicles.

National Transport Policy

- Setting rules for the allowance of platooning on (specific part of) the road network.

Milestones

By 2020:

- Demonstration projects, national legislation and EC regulation.
- Platooning introduced on specific roads in 2020 and beyond.

By 2035:

- Platooning allowed on all EU highways in 2035 (freight and passengers).
- First vehicles without drivers and start of 'intelligent cargo' in 2035.

9.23 Action 22 – Standardized Loading Units

Ronald Jorna and Hans Zuiver

9.23.1 Introduction

Current multitude of different transport configurations creates friction costs and unnecessary delays in handling operations between transport modes. Standardizing an EU loading unit could offer a solution by combining the benefits of containers and those of swap bodies. This EU Intermodal Loading Unit (EILU) should be able to move freely in all modes of transport and between them in order to ensure maximum co-modality.

9.23.2 Assessment

Experience and Feasibility

The EILU could bring improvements in terminal productivity, primarily through more efficient use of handling equipment. However, the existing loading units have been developed for different kinds of goods. While a standardized loading unit may simplify trans-shipment operations, the specific advantages of specialized units would be lost. This could lead to a modal shift back to the road where such specialized equipment would most probably still be offered. It also requires investments in new loading units. Overall, it is not yet certain the effects are beneficial for society as a whole.

Reduction Potential

Table 9.22 Reduction potential – standardized loading units

GHG	– to +
FFS	0
Road fatalities	0
Congestion	0

Pro Arguments:

- The EILU combines the benefits of both containers and swap bodies
- Trans-shipment between modes would be simplified
- Efficiency benefits in logistics may be obtained

Contra Arguments:

- New container standards should be taken at international level
- Operators, terminals and transporters have to adapt their equipment to the new EILU
- In the transition period two sizes will have to coexist next to each other, increasing logistic costs

Conclusion

An update on the 2003 proposal on the EILU was scheduled for 2008. However, no significant progress has been made so far. When designing a new intermodal loading unit, the Commission should not ignore the standards employed outside the EU and units employed in deep-sea trade. Moreover, the specific advantages of current loading units will be lost by the introduction of the EILU. These possible negative consequences should therefore be examined in detail.

Not Recommended

9.24 Action 23 – E-freight

Ronald Jorna and Hans Zuiver

9.24.1 Introduction

E-freight helps to promote co-modality by providing dynamic multi-modal door-to-door travel information, minimizing paperwork and unproductive repetitive processes,

lowering costs and making co-modal solutions more effective and therefore more competitive. It denotes the vision of a paper-free, electronic flow of information associating the physical flow of goods with a paperless trail built by ICT.

9.24.2 Assessment

Experience and Feasibility

The e-Freight concept was included in the Freight Logistics Action Plan of 2007 and the ITS Action Plan of 2009. On short term a research project on e-freight will start, completing the jigsaw of research done so fare. It will also develop the e-freight roadmap and coordinate the research outputs to that end.

A number of obstacles still need to be overcome, including the insufficient standardization of the respective information exchanges and market actors' disparate capabilities to use ICT. It should also be noticed that for transport service providers the advantages in advertising services on the Internet using the e-freight concept do not automatically outweigh the disadvantages of competitors being able to see the services offered.

It is however expected that the socio-economic benefits (productivity and logistics costs) outweigh the business disadvantages of specific companies.

Company/Market Perspective

With the help of e-freight:

- Shippers, freight forwarders etc. are able to identify and use direct or combined transport services most suited for their purpose;
- Transport service providers can exchange information electronically with actors across the different modes;
- Infrastructure providers are able to facilitate the best possible use of infra by providing information about the available transport infrastructure and how to use it.

Reduction Potential

Table 9.23 Reduction potential – e-freight

GHG	++
FFS	0
Road fatalities	+
Congestion	0

Pro Arguments:

- It helps to make logistics processes more efficient
- It helps to encourage customers trust in co-modality
- It supports the single transport document
- Compared to other actions, it is a relative simple and inexpensive action

Contra Arguments:

- A number of technical obstacles need to be overcome
- Transport operators need to adapt existing information systems
- Transport companies are not in favour of market transparency

Conclusion

Positive impacts on GHG emissions, congestion and road fatalities are expected (indirect through modal shift), but no quantitative figures can be given at this moment.

Highly Recommended

9.24.3 Recommended Tasks and Milestones

RTD Policy

ITS technologies are essential for the implementation of e-freight. To establish a roadmap for the development of an integrated ICT application, the following research is needed.

- Platform to support the design, development, deployment and maintenance of e-freight solutions for all modes.
- Interoperability and standardization of e-freight services.
- Dissemination of best practices

Demonstration Projects

Identification of e-freight services, development of actions and translation of project results in business cases.

Transport Policy

The e-freight concept was included in the Freight Logistics Action Plan of 2007. The ITS Action Plan stressed the importance of ITS applications for freight transport and in particular e-freight. The EU Parliament approved this plan in April 2009.

European Transport Policy

- Development of a Roadmap for the adoption of e-freight, identifying the problem areas where action such as standardization is required.
- Proposal for a uniform ICT platform (single-window) to be used by stakeholders on a voluntary base.
- Strong support for standardization.

National Transport Policy

- Harmonization of e-freight related tools used already across the different transport modes.

Milestones

By 2020:

- RTD and demonstration projects finalized by 2015
- E-freight platform fully operational and accessible by all stakeholders by 2020.

9.25 Action 24 – Network Optimization – Cargo Owner

Gerhard Bauer, Werner Jammernegg, and Heidrun Rosič

9.25.1 Introduction

Strategic network design deals with the number, location and function of the facilities of a cargo owner and therewith mainly determines a company's transport demand. Two main possibilities in order to counteract congestion and CO_2 emissions are onshoring and flexible supply base. Whereas onshoring means to relocate production closer to the demanding unit, flexible supply base is a mixed version of off- and onshoring. It provides on the one hand the possibility to serve the basic demand from an offshore facility and on the other hand the company is flexible enough to react to demand fluctuations and disruptions like delivery delays due to, for example, congestion.

9.25.2 Assessment

Experience and Feasibility

In the long run companies will have to re-evaluate their network design because of a number of reasons. First of all, regulations of carbon emissions are getting

tighter. Secondly, companies have to respond to higher and more volatile fuel prices. Thirdly, evolving customer awareness might lead to a partially switch of demand to companies which supply products with a desirable carbon footprint. Finally, the increasing importance of "soft" factors, like delivery time, flexibility and risk already forces companies to build production facilities closer to the market. The World Economic Forum agreed on a worldwide reduction potential of 5 MT of CO_2 for nearshoring.

Company/Market Perspective

The most relevant market players affected by this action are cargo owners, logistics service providers and consumers:

- Cargo owners will adjust their network design in order to reach their strategic objectives. Nevertheless, policy actions which favour onshoring and flexible supply base might increase costs and, therefore, might encounter resistance. –
- Logistics service providers: If the redesign of the cargo owner's network results in the reduction of the transport distance the demand for this service goes down. Therefore, adjustments of cargo owners aiming at a reduction of CO_2 go to the expense of logistics service providers' demand. –
- Consumers: Network Optimization should lead to the reduction of CO_2 emissions. Assuming that consumer awareness increases with respect to the environment they will honour the cargo owner's actions. But if the actions are accompanied by an increase of prices their positive attitude will diminish. – to +

Reduction Potential

Table 9.24 Reduction potential – network optimisation – cargo owner

GHG	++
FFS	0
Road fatalities	+
Congestion	++

Pro Arguments:

- Significant reduction of overseas transport demand
- Reduced utilization of the main road corridors
- Reduced utilization of the main terminals and ports
- Increased flexibility to react to disruptions, like delivery delays due to congestion

Contra Arguments:

- Huge investments
- Long-term switch of paradigm
- Highly dependent on preconditions (tighter regulations, higher oil price, customer awareness)
- Increased costs (e.g. wages)

Conclusion

The preconditions are very likely and therefore companies will in the long run have to re-evaluate their network design. Nearshoring and flexible supply base are suitable to improve a company's carbon footprint even if the potential calculated by the World Economic Forum is not very high.

Nevertheless, due to the fact that transcontinental transport is excluded the action has limited impact on the key indicators as they are defined in FREIGHTVISION and therefore is not highly recommended, but recommended.

9.25.3 Recommended Tasks and Milestones

RTD Policy

No new technologies are necessary for network optimization. Consequently, there is no need for basic and applied research and demonstration projects.

Transport Policy

An increase in transport costs favours a location closer to the market. This is due to the fact that the advantages of offshoring (e.g. low labour costs) diminish as the costs of transport get higher.

Policy actions have to be set on a European level. They have to directly address the CO_2 emissions caused by transport. Two opportunities of transport policy actions would therefore be the integration of transport in the EU Emission Trading Scheme or a toll considering mileage and engine efficiency as discussed in the Netherlands.

Milestones

Network optimization from a cargo owner's perspective is mainly linked to actions increasing the transport costs like Internalization of external costs and taxation of fossil fuels. The actions would partially diminish the advantage of low labour costs and would, therefore, favour onshoring and flexible supply base.

Additionally, network optimization is linked to the introduction of a standardized CO_2 Label. A current study has shown that a label could have a significant influence on the consumers' brand choice.

9.26 Action 25 – Network Optimization – Logistics Service Provider

Gerhard Bauer, Werner Jammernegg, and Heidrun Rosič

9.26.1 Introduction

Network optimization from a logistics service provider's perspective deals with the number and location of inventory facilities. In order to reduce the distance to the customer, this action intends to counteract the prevailing logistics trend of centralization. A logistics service provider mainly considers storage and trans-shipment centres in designing its network. They have to choose between a centralized and a decentralized distribution and procurement network. Of course, cargo owners, as well, have to bear these decisions in mind when they perform their procurement, distribution and storage tasks in-house.

9.26.2 Assessment

Experience and Feasibility

In the last decade, the trade-off between transport and inventory costs often led to the centralization of inventories as the transport costs were negligible and "soft" factors like, for instance, delivery reliability were not considered (McKinnon and Forster 2000, p.7). This advantage might change soon as companies face higher and more volatile fuel prices. Furthermore, tighter regulations of carbon emissions and evolving customer awareness might force companies to include environmental key figures like the carbon footprint in their network design decisions and therewith decentralization will be favoured. A US company from the apparel industry, for example, decreased their CO_2 emissions by 25% by opening two additional distribution centres (Simchi-Levi 2008).

Company/Market Perspective

Logistics service providers, cargo owners and consumers are the most relevant market players affected by the action network optimization from the perspective of a logistics service provider:

- Logistics service providers: The implementation of the action implies additional costs for further storage facilities and the needed workforce. Nevertheless, shorter

distances to the customer increase the transport reliability and therewith improve the performance. – to ±

- Cargo owner: Similarly to the logistics service providers, a cargo owner might also face higher transport costs but on the other hand improves its customer performance. – to ±
- Consumers demand products with a lower carbon footprint. This is triggered by increasing customer awareness. However, as additional costs might incur the price might also go up. ±

Reduction Potential

Table 9.25 Reduction potential – network optimization – logistics service provider

GHG	+++
FFS	0
Road fatalities	+
Congestion	++

Pro Arguments:

- Significant reduction of transport demand
- Increased flexibility to react to changes of customer demand
- Reduced utilization of overloaded terminals and links

Contra Arguments:

- Huge investment
- Highly dependent on preconditions (tighter regulations, higher oil price, customer awareness)
- Increased inventory costs

Conclusion

If the preconditions are fulfilled the huge initial investments will be justified within a short period of time. Decentralization is a very effective way to reduce CO_2 emissions. But it is also a very good action to reduce the utilization of overloaded terminals and corridors.

As a result, decentralization is **highly recommended** as a long-term action.

9.26.3 Recommended Tasks and Milestones

RTD Policy

No new technologies are necessary for network optimization. Consequently, there is no need for basic and applied research and demonstration projects.

Transport Policy

An increase in transport costs favours the decentralization of inventories. This is due to the fact that the pooling effect of inventory aggregation diminishes as the costs of transport increase.

Policy actions have to directly address the CO_2 emissions caused by transport and they have to be introduced on an European level. Two opportunities of transport policy actions would therefore be the integration of transport in the EU Emission Trading Scheme or a mileage dependent toll considering the CO_2 emissions of different engines as discussed in the Netherlands.

9.27 Action 26 – CO_2 Labels

Gerhard Bauer, Werner Jammernegg, and Heidrun Rosič

9.27.1 Introduction

A CO_2-label is a tag on a product to inform the customer about a product's carbon footprint. The carbon footprint is defined as the "total set of greenhouse gas emissions caused directly and indirectly by an individual, event, organization or product expressed as CO_2-equivalents" (Carbon Trust 2009). It is aimed to be calculated in accordance with international standardized rules and therewith enables the customer to choose the product not only on the basis of price but also based on its climate impact.

9.27.2 Assessment

Experience and Feasibility

At the moment, numerous initiatives by public or private companies, for instance, in Austria, UK and France are under way in order to provide reliable environmental information to consumers. Walkers, a British company producing crisps, already adopted the carbon reduction label of carbon trust. Two surveys conducted after the carbon reduction label was launched in July 2007 show that consumers react in a positive way and seem to use the information properly to reduce the carbon footprint of their regular

shopping items (Carbon Trust 2008). Furthermore, almost half of the people surveyed said that the label changed their perception of Walkers in a positive way. Nevertheless, a carbon label has to be regulated by law. Otherwise, a comparable CO_2-label would only be adopted by the best performing company.

Company/Market Perspective

The CO_2 label affects the consumers and all companies in a supply chain.

- Cargo owners bare the costs of using more expensive but more environmental friendly resources. Nevertheless, best performer and first mover can gain a marketing advantage. Consequently, a CO_2 Label might lead to increasing sales. − to +
- All companies in the supply chain are forced to improve their own carbon performance in order to reduce a product's carbon footprint. − to +
- Consumers have the possibility to choose products with regards to their carbon footprint. Prices might increase as the costs of more environmentally conscious strategies might be reflected in the price. − to +

Reduction Potential

Table 9.26 Reduction potential – CO_2 labels

GHG	+++
FFS	+
Road fatalities	0
Congestion	+

Pro Arguments:

- Important prerequisite for companies to act in favour of the environment
- Increases customer awareness
- Comparability of goods on the basis of environmental impact

Contra Arguments:

- Requires standardization
- High costs of implementation
- Need for traceable calculation methodology
- Missing reliability of not standardized and certified labels
- Need for legal obligation

Conclusion

The CO_2-Label will still take some time (up to 20 years) to develop its impact on customer demand. But it is a very important prerequisite to encourage companies to act in favour of the environment and to adopt actions like "network optimization", "intermodal transport", "transport consolidation/cooperation" and "transport route planning and control".

Highly recommended,
as it is a prerequisite to encourage companies to act in favour of the environment.

9.27.3 Recommended Tasks and Milestones

RTD Policy

The methodology to calculate a product's carbon footprint has to be standardized. This has to be done on an EU-wide (supported by CEN) or even global level (supported by ISO)

The standardized methodology defined in previous steps has to be implemented in integrated information systems.

Demonstration Projects

Implementation of the CO_2 Label in certain regions for certain groups of products.

Milestones

By 2020:

- The demonstration projects and the standardization process should be finished.
- The legal obligation should also be set until 2020.

9.28 Action 27 – Intermodal Transport

Gerhard Bauer, Werner Jammernegg, Heidrun Rosič, Olaf Meyer-Rühle, and Kristin Stefan

9.28.1 Introduction

More than 80% of the European freight transport is carried by trucks (short sea shipping excluded). This is due to a number of reasons, like speed, flexibility and dense road infrastructure. Nevertheless, road is certainly not environmental friendly compared to rail and inland waterways. Therefore, a number of efforts were taken by the European Union and national governments to promote intermodal transport which means that

transport is carried out by at least two modes. One example is Marco Polo, a funding program of the European Union for projects which are intended to shift transport from road to rail, inland waterways and sea. But the feasibility of intermodal transport (IMT) depends on the transported products and their industry, as well as the different characteristics (speed, flexibility, reliability, network density etc.) of road, rail and inland waterway (IWW). Today the largest problems of IMT are the slowness and inflexibility/unreliability of rail and IWW, bottlenecks in terminal capacity, inefficiency of trans-shipment technology as well as information gaps concerning existing advantages and applications of IMT (Schmidt and Kille 2008, pp. 53).

9.28.2 Assessment

Experience and Feasibility

A company has to rethink its modal choice due to tighter regulations and higher and more volatile fuel prices. Nevertheless, intermodal transport is often not preferred by companies as it might have a significant negative impact on the delivery time and flexibility of a company due to, for instance, the long and unpredictable terminal transit times (de Brito et al., 2008). Additionally, it has to be kept in mind that the main constraining factor for intermodal transport is the lack of infrastructure. For example semi-trailers and other types of consolidated loads are prerequisites but only 2% of them are equipped for intermodal transport (Savelsberg 2008, p.19). Furthermore, the remaining capacity of the rail network is quite low.

Company/Market Perspective

Shippers and all actors in the logistics chain are concerned with this action.

- Shippers may impose less restrictive time windows in order to allow more (energy and environmentally) efficient transport chains.
- For freight forwarders/logistics companies, an increased share of IMT means more planning due to more complex transport chains.
- Shippers and carriers can take advantage of decreasing environmental impact of their transport activities.

Reduction Potential

Table 9.27 Reduction potential – intermodal transport

GHG	+++
FFS	++
Road fatalities	+
Congestion	+

Pro Arguments:

- Reduced utilization on main road corridors
- Increased use of more environmental friendly modes
- Significant reductions of GHG

Contra Arguments:

- Lacking capacity of trans-shipment terminals
- Huge investments in capacity of rail network required
- Time losses due to lacking interoperability between certain European countries (rail)
- Reduced flexibility
- Longer delivery times

Conclusion

Numerous efforts were taken by the European Union and national governments to increase the share of intermodal transport. Nevertheless, huge investments in infrastructure (terminals, networks, compatible vehicles) would be necessary to improve the performance of intermodal transport.

As it has a huge impact on CO_2 emissions and road congestion, these investments might be justified and we, therefore, highly recommend this action.

9.28.3 Recommended Tasks and Milestones

RTD Policy

All technologies that are needed to operate IMT exist already and have been tested successfully in several demonstration projects. Even programs to promote Intermodal Transport were set up. But it could be helpful to deal with questions of missing IT interfaces/links as well as the automation of trans-shipments.

Transport Policy

Because environmental aspects become more and more important the European Union as well as EU Member States took efforts to promote IMT. There are political objectives of transport policy (see White Paper) but there are no laws or directives to enforce IMT.

European Transport Policy

Strengthening/extension of the Marco Polo program and an optimized strategy of investments in terminals and transloading units across Europe.

National Transport Policy

National logistics action plans to strengthen intermodal transport.

Milestones

By 2020:

- 50% of sea container transport over 500 km will be by rail or IWW.

By 2035:

- 75% of sea container transport over 500 km will be by rail or IWW.

By 2050:

- 90% of sea container transport over 500 km will be by rail or IWW.

9.29 Action 28 – Transport Consolidation and Cooperation

Gerhard Bauer, Werner Jammernegg, and Heidrun Rosič

9.29.1 Introduction

Transport consolidation and cooperation means to merge deliveries in order to improve performance actions like the load factor or empty runs. This is often done by third party logistics which have the possibility to consolidate shipments of different companies. Alternatively, companies can cooperate on an individual basis in order to increase transport efficiency and therewith reduce costs and environmental impact.

9.29.2 Assessment

Experience and Feasibility

Transport consolidation and cooperation is an action which can be implemented within a very short period of time, especially when third party logistics are involved. Furthermore, a company can save money as the number of trucks needed is reduced.

A good example for consolidation is the European company Teleroute (2009). It offers a variety of freight exchange solutions in order to increase the utilization of trucks. The companies can connect to a common database, which is updated in real time, and thereby match freight with available vehicle space.

Company/Market Perspective

The most relevant market players affected by this action are cargo owners, logistics service providers and consumers:

- Cargo owner: A cargo owner increases its load factor and reduces empty runs. Furthermore, not fully loaded trucks are shared with other companies. Consequently, a cargo owner reduces its transport costs. Nevertheless, sharing transport units also implies the sharing of information. This might hinder the implementation of the action especially when competing companies could share transport. − to +
- Logistics service providers: Consolidated shipments increase the load factor. As the price which has to be paid for this service remains, a logistics service provider's profit margin increases. +
- Consumers: The reduction of transport costs for cargo owners might be reflected in the price. +

Reduction Potential

Table 9.28 Reduction potential – transport consolidation and cooperation

GHG	++
FFS	0
Road fatalities	0
Congestion	+

Pro Arguments:

- Increased load factor, less empty runs less traffic
- Reduction of transport costs
- Implementation within a very short period of time

Contra Arguments:

- Possible impact on key indicators highly depends on industry
- Increased administration costs

Conclusion

Transport consolidation and cooperation can be implemented in a very short period of time. Furthermore, it mostly leads to a reduction of costs. It has a big potential to improve the key indicators as the average load factor is less than 50% and almost a quarter of all trucks are running empty. Nevertheless, the potential must not be overestimated as some trucks are not compatible with certain goods. A case study analyzing

a British food supply chain, for instance, shows that the potential to reduce empty runs for goods needing special refrigerated trucks is not more than 2% (McKinnon and Ge 2006).

Nevertheless, as cost and CO_2 emissions can be reduced, this action is highly recommended.

9.29.3 Recommended Tasks and Milestones

RTD Policy

Improvements in order to provide data security for competing companies which merge their transports have to be achieved.

Transport Policy

Several transport policy action can be set on national and/or European level in order to favour transport consolidation and cooperation. Empty runs or even not fully loaded trucks could be punished with a penalty fee. Alternatively, transport could be integrated in the EU Emission Trading Scheme. Finally, a mileage dependent toll considering the CO_2 emissions of different engines as discussed in the Netherlands would also favour the implementation of this action.

9.30 Action 29 – Transport Route Planning and Control

Gerhard Bauer, Werner Jammernegg, and Heidrun Rosič

9.30.1 Introduction

Transport route planning and control includes two types of decisions, first, to find in advance the optimal route between a facility and the demanding unit (including information about frequently congested corridors) and second, real-time route planning based on information about disruptions on certain links, like congestion and road fatalities. These decisions are supported by certain applications of advanced planning systems and by GPS-based navigation systems in combination with real-time information through traffic message channels.

9.30.2 Assessment

Experience and Feasibility

The diffusion of advanced planning systems (APS) and GPS-based navigation systems increases. If APS remain expensive, the diffusion will not grow in the same pace as navigation systems which have already got standard equipment in new vehicles. A case

study carried out in a Swedish city called Lund found out that rerouting based on real-time information of traffic disturbances not only saved fuel but also time (~ 15%, Ericsson et. Al. 2006). As a result, companies are able to avoid congestion and reduce their carbon footprint.

Company/Market Perspective

Logistics service providers and consumers are the most relevant market players affected by the action transport route planning and control:

- Logistics service providers: Implementing transport route planning and control reduces the transport distance and the time stuck in congestion. Consequently, the reliability of delivery and delivery times increase, while the transport costs decrease. ++
- Consumers: The action improves a company's customer performance without the need to increase the price ++

Reduction Potential

Table 9.29 Reduction potential – transport route planning and control

GHG	++
FFS	0
Road fatalities	+
Congestion	+

Pro Arguments:

- Technology already available
- GPS using TMC almost standard
- Significant influence on CO_2 emissions and congestion

Contra Arguments:

- Probably high implementation cost, depending on technology used
- Depends on the diffusion and quality of the traffic message channels

Conclusion

Transport route planning and control will play a big role, especially until 2020, for reducing a company's carbon footprint, as it can be implemented within a very short period of time and the necessary technologies are widely available. It has a remarkable influence on the key indicators, especially on CO_2 emissions. However, the utilization

of stressed links decreases as well because the vehicles get rerouted based on real-time information about disturbances.

Highly recommended, as it can be implemented ad hoc and the necessary technologies are widely available.

9.30.3 Recommended Tasks and Milestones

RTD Policy

Improving software solutions in order to display available real-time data on disturbed links.

Integration of planning and control software as recent data on congestion used in transport control devices should also influence the transport route planning.

Integration of all modes in transport route planning and control software.

Demonstration Projects

Evaluation of the impact of more precise real-time information on the length and duration of congestion.

Transport Policy

The foreseen mileage dependent toll in the Netherlands is to be calculated on the basis of information provided by GPS sensors in passenger and freight vehicles. These sensors could be used in order to calculate the distance travelled as well as to determine the utilization of the roads.

Milestones

The integration of planning and control software should be finished by 2020. The availability of the needed data on congestion highly depends on the development of ITS. As this process should be finished by 2035, the implementation of the demonstration projects should also be finished by 2035.

9.31 Action 30 – Taxation of Fossil Fuels

David Bonilla and Nihan Akyelken

9.31.1 Introduction

Fuel taxes generally increase as oil price falls, and fall when oil price rises; this is called the fiscal drag. Fuel taxes can also work as revenue raising devices, pollution abatement

ones and in general as a way to internalize externalities. Diesel taxes are around 70% of final (tax inclusive; based on IEA, 2008) diesel price. This final price is the retail price to freight companies or consumers.

The action is a hybrid approach involving: direct CO_2 taxes and CO_2 trading scheme of LDFT (all market-based). This will favour adoption of low carbon fuels and reduce fossil fuel use of LDFT.

9.31.2 Assessment

Experience and Feasibility

Higher taxes on fuel may affect employment, on the one hand, by raising fuel cost of freight companies engaged in LDFT. The economic feasibility of a fuel tax depends on four areas: competitiveness, harmonization efforts, of fuel tax, within the EU, employment and the CO_2 tax architecture.

Company/Market Perspective

Logistics and freight companies and vehicle suppliers are negatively affected by the action, whereas treasury/inland revenue services and infrastructure operators should benefit from the action through increased revenue for public investment.

Reduction Potential

Table 9.30 Reduction potential – taxation of fossil fuels

GHG	+++
FFS	+++
Road fatalities	+
Congestion	+

Pro Arguments:

- Targets production chain early on
- Provides incentive to producers and consumers alike to cut fuel use
- Fully comprehensive: covers truck makers, freight companies and the like.
- Compensates the losers (truck fleets with high energy intensity)

Contra Arguments:

- An imperfect price instrument as it is mixed up with a massive transfer of financial resources

- Lack of agreement on how heavily fossil fuel (or CO_2) should be taxed among EU27 Governments of Member States
- Fails to give certainty on how the reduction in CO_2 will be

Conclusion

Taxes impact on fuel prices sending the right signals to producers to act and to internalize the externality. The effect will be lower on congestion and on road fatalities. Ideally taxes should be set according to the level of environmental damage that each of fossil fuel generates. This, however, is not the case in the EU27. For example, taxes on coal are lower than taxes on oil and coal is the least heavily taxed in the EU.

Recommended

9.31.3 Recommended Tasks and Milestones

RTD Policy

- Research on the effects of carbon tax on new truck markets, on consumers of fuel and modal split and on CO_2 emissions of truck fleets as well as research on price elasticity.
- The increased fossil fuel taxes inside the EU27 Member States shall be used for RTD subsidies.

Transport Policy

In the EU27, taxes are not set according to the level of environmental damage that each of fossil fuel generates. For example, taxes on coal are lower than taxes on oil and coal is the least heavily taxed in the EU.

European Transport Policy

EU transport policy will have to adapt to (1) EU climate policy targets and (2) actions adopted under a quantitative agreement (Kyoto/Copenhagen style) of CO_2 emissions. The action should apply to all fossil fuels sold in the freight transport sector and to fuel use. Hundred percent revenue recycling is also important. A potential action plan for carbon trading (operating as a fuel tax) related to transport would be:

- Determine (1) who trades CO_2 of LDFT, (2) the CO_2 emissions cap and set a long-term CO_2 reduction target for the scheme
- Require companies and government agencies to collect data on CO_2 within their supply chain of LDFT movements
- Harmonize CO_2 tax levels for all transport fuels used for transport in EU region.

Milestones

By 2020:

- A price for CO_2 has been set
- It has been decided who (vehicle maker or freight com.) trades CO_2;
- Emissions allocation among EU-27 nations has been determined

By 2035:

- CO_2 emissions cap for LDFT has been further tightened.
- The losers of the fuel tax and CO_2 tax are compensated.

9.32 Action 31 – Hydrogen Infrastructure

Julia Düh, reviewed by Tuomas Mattila

9.32.1 Introduction

The production, storage and the distribution of hydrogen for long-distance freight transport has a considerable potential but needs further research. Significant improvements in the production of hydrogen from renewable sources are needed to avoid negative impacts on GHG emissions.

There are several technological options to produce, store and use hydrogen in transport. However, for heavy duty long distance freight transport, compressed hydrogen (CGH_2) and liquid hydrogen (LH_2) have too low energy density for internal combustion engines and complex storage. Therefore fuel cells are a prerequisite for hydrogen use (OECD, 2006).

9.32.2 Assessment

Experience and Feasibility

No OEMs (Original Equipment Manufacturer) are currently considering developing H_2 internal combustion engine for HGVs. However, over the past decades there have been numerous high profile fleet trials of H_2 buses (e.g. HyFLEET:CUTE project) (src.: Global Hydrogen Bus Platform).

The use of hydrogen as an energy source for long distance freight transport can reduce GHG emissions and fossil fuel share but only if the hydrogen production is not gas or coal-based.

Many activities are under way, such as Fuel Cells and Hydrogen Initiative (FCH) (2008–2017) funded by the European Community and private sector. Other activities

include such as Fuel Cells and Hydrogen Initiative (FCH) with budget (2008–2017) € 1.0 billion (European Community: € 0.5 billion, Private sector: € 0.5 billion) the project HyWAYS (EU-funded project assessing hydrogen's potential socioeconomic impacts) showed that Up-front costs would need to be balanced against savings from replacing conventional fuel and vehicles, with a break-even point expected between 2025 and 2035 (EU-Focus, 2009).

Company/Market Perspective

The most relevant market players affected by this action are

- Vehicle suppliers +
- Electricity companies and energy supplier +
- Developers of fuel cells +
- Road logistic and freight transport companies +
- Rail companies –
- Infrastructure operators –
- Oil companies –

Reduction Potential

Table 9.31 Reduction potential – hydrogen infrastructure

GHG	− to +
FFS	++
Road fatalities	− to 0
Congestion	0

Pro Arguments:

- CO_2 emission are near zero as hydrogen is a non-carbon fuel
- Future technologies may reduce the costs of hydrogen production
- Reduction of the total oil consumption of the road transport sector, if the hydrogen is not produced out of coal

Contra Arguments:

- Hydrogen production far away from being commercially viable
- Storage of LH_2 implicates boil off problem, safety impacts unknown
- Lack of infrastructure for refueling hydrogen vehicles limits the uptake and use of H_2 technology
- Requires new infrastructure

Conclusion

The production, storage and the distribution of hydrogen for long distance freight transport is far from being commercially available. Significant improvements in the production of hydrogen are needed to avoid negative impacts on GHG emissions. This action is recommended if no fossil fuel is used for producing hydrogen.

(Not) Recommended

9.32.3 Recommended Tasks and Milestones

RTD Policy

Demand for research concerning the improvement of hydrogen production and the application of hydrogen fuel cells for LDFT:

- Integrated impact assessment (Cost-benefit analysis)
- Technology assessment
- Concept for the production and storage of hydrogen for LDFT
- Green corridor for testing alternative mobility

Demonstration Projects

- R&D hydrogen fuel cell – energy density
- Energy density hydrogen storage – Demonstration: different fuel cell
- Hydrogen heavy duty vehicle with hydrogen storage
- Demonstration of low cost zero-carbon hydrogen production

Transport Policy

The current governance regime is that hydrogen infrastructure is a desirable aim but only on the long term.

European Transport Policy

Strengthening the activities which are supported by the automotive industry and the EC such as Joint Technology Initiatives (JTI).

Milestones

By 2020:

- CO_2 free hydrogen products portfolio should be available. Beginning of building up a wide hydrogen infrastructure

- 100,000 cars and busses over life cycle commercially available
- the FC implementation should be achieved
- Infrastructure development driven by passenger transport, full coverage up to 2020 (in Germany)
- Green corridor implemented as a test bed for alternative mobility

By 2035:

- Hydrogen usable for road freight

By 2050:

- Full FC in HDV has very low probability

9.33 Action 32 – Improved Batteries (Energy Storage)

Riina Antikainen and Tuomas Mattila

9.33.1 Introduction

The aim of improved batteries is to facilitate electric power use in heavy trucks, which is currently limited by the low energy density of present batteries. Very high efficiency of the electric engine provides great potential for reducing the energy demand of road transport.

The low energy density, low durability and high cost of current batteries prevent the use of all-electric trucks. However the field is under research and some promising prototypes have been proposed. These include nanowired lithium batteries for size reduction, specialty coating for shorter recharging periods and the development of high capacity ultracapacitors. (Chan et al., 2008; Kang et al., 2006)

9.33.2 Assessment

Experience and Feasibility

Light electric trucks and vans are already used in delivery by companies such as UPS and TNT. In addition they have been introduced to short distance, heavy duty transport in ports and airports. However the low-energy density of the lead acid battery and the high cost of the lithium ion battery have limited their use in long distance heavy transport, where the amount of energy stored on board is significant. Nanowired lithium batteries and ultracapacitors solve this problem, but they are not yet commercially produced. The nanowired lithium batteries are based on conventional electronics and could be commercial in a few years. The first commercial electric vehicles based on ultracapacitors are planned to be released this year. If the vehicles could be charged during operation

(i.e. through induction charging or by overhead cables) the size of batteries could be reduced considerably.

Company/Market Perspective

Electric propulsion will result in reduced operating costs for road logistics and freight transport companies. In addition vehicle suppliers and electricity companies will benefit from increased demand. Rail companies will suffer from increased competition through low-cost road freight and oil companies will lose revenues. Tax revenues from fossil fuels will be reduced. The development of electric propulsion will compete with other alternative fuels for research and development funds.

Reduction Potential

Table 9.32 Reduction potential – improved batteries (energy storage)

GHG	+++
FFS	++
Road fatalities	+
Congestion	0

Pro Arguments:

- Effective in reducing GHG and fossil fuel share
- Reduces fuel and engine maintenance costs
- Improves potential for renewable energy production through storages
- Removes noise and much of particle and other air pollutant emissions from traffic
- Stimulates technology development in all modes (including all electric ships)

Contra Arguments:

- Optimal benefits require clean electricity production
- Technology is still at a prototype stage, first models may not be reliable
- May require dedicated charging stations (infrastructure costs)
- Increases demand for electricity production
- Includes safety risks (explosion of the battery)
- Resource availability (e.g. rare metal) may limit the application

Conclusion

Current batteries are unsuitable for long-distance heavy freight transport. However several developments are on the way in applied research. Bringing state of the art technology to the commercial market would make it possible to have all electric

fleets. Improved energy storage in the transport sector would affect the whole energy production and distribution sector.

In spite of risks, early investments to commercialization of energy storage systems are highly recommended, but more information is needed on the comparative costs in relation to other actions and the role of different stakeholders in promoting the action.

9.33.3 Recommended Tasks and Milestones

RTD Policy

- Dedicated electric long distance lanes with mobile recharging would make it possible to have electric vehicles without having to wait for improved batteries to provide energy for all the operation range needed. These could be integrated to the rail structure
- To facilitate the spread of improved batteries, demonstration projects for improved batteries in heavy goods vehicles are necessary. This would reduce the barriers for moving new technology into mainstream manufacturing
- Gradual electrification beginning with auxiliary power (AC, loading, etc.) and continuing with the lengthening of battery powered operation distance when new battery materials become feasible for commercial operation

Transport Policy

- Synergy with the electrification of passenger transport

Milestones

By 2020:

- The first electric truck lanes in operation
- Battery powered operation demonstrated during loading and offloading

By 2035:

- Development of technology and equipment to such that a day's operation (c.a. 600 km) can be achieved without recharging

By 2050:

- Electricity powered operation carries the most heavy goods (for energy efficiency) and delivery within cities (for low noise and zero emissions)
- Electric propulsion has also made underground roads possible, reducing transport distances and congestion

9.34 Action 33 – Including CO_2 Standards into HGV Regulations (EURO6)

Riina Antikainen and Tuomas Mattila

9.34.1 Introduction

The EURO standards have been proven successful in controlling non-CO_2 (traditional air pollutants). The inclusion of greenhouse gases (GHGs, of which CO_2 gas is the most important in the context of transport) in the EURO standards would seem to be an efficient way to control climate change and fossil fuel share. Currently, no GHG targets for heavy duty vehicles have been set by the EU Commission and political opposition to a GHG standard is expected.

9.34.2 Assessment

Experience and Feasibility

The EURO standards have been applied in Europe since early 1990s, and similar regulations exist in many other countries such as USA, Australia and Japan. The EURO norms for heavy duty vehicles are based on the current engine and fuel choice, i.e. the diesel engine. These norms only apply to traditional non-CO_2 pollutants. While for passenger cars and other light vehicles, the emissions limits are defined in g/km and for other pollutants, limits for heavy duty vehicles are defined by engine power (g/kWh) (EC 2010a, 2010b). This makes comparison of the test results difficult and is not encouraging energy efficient vehicle design. Therefore a distance-based emission limit (g- CO_2/km) is seen more motivating in terms of GHG reduction and energy efficiency improvements. The heterogeneity of the truck stock and the extra capital cost makes it difficult to implement GHG limits on trucks in the EU27 States.

Company/Market Perspective

Environmental, energy and technology policy makers and technology developers are the main players. Diesel technology developers would benefit from the demand of improved engines, but the net effect to passenger and HGV vehicle suppliers as well as hauliers remains uncertain.

Reduction Potential

Table 9.33 Reduction potential – including CO2 standards into HGV regulations (EURO6)

GHG	++
FFS	0
Road fatalities	0
Congestion	0

Pro Arguments:

- Good potential for greenhouse gas emission reduction in relatively short time horizon
- Obligatory action is equal for all similar technologies

Contra Arguments:

- The concept designed for diesel engines only; therefore not high potential in the long run
- Does not control upstream emissions
- Requires administrative and regulative actions to be implemented

Conclusion

Including GHGs into EURO norms seem to be an efficient way to reduce emissions in a relatively short time horizon. In the long run, however, other actions are likely to be more efficient actions to reduce GHGs and improve energy efficiency.

Recommended due to the good experiences on traditional air pollutants. The action is also recommended for short distance transport.

9.34.3 Recommended Tasks and Milestones

RTD Policy

Heavy duty vehicles' emission limits are defined by engine power (g-CO_2/kWh), which makes comparisons, among trucks, of the test results difficult and that metric does not encourage energy efficient vehicle design. Therefore a distance-based emission limit (g-CO_2/km) in test cycles is seen as more motivating action in terms of GHG reduction and energy efficiency improvements. Support on technological development (especially engine efficiency, aerodynamics, rolling resistance) is needed.

Transport Policy

European or Member State financial support (e.g. lower taxes or congestion charges) to promote technological development and to support acquisition of advanced vehicles.

Milestones

By 2020:

- Development of, and agreement on, test cycles for CO_2 in diesel engines

- Technological development on heavy duty engine efficiency, rolling resistance and aerodynamics
- Policy action: agreement on the CO_2 emission level and possible reduction rate
- EU legislation and national implementation of CO_2 standards

By 2035:

- Continuous improvement of technologies and vehicles
- Updates of the emission limits and the legislation

By 2050:

- Assessment of the feasibility of the action; is it still relevant or are the other actions more powerful in emission reduction?

9.35 Action 34 – BAT Vehicle Certification for Heavy Goods Vehicles

Riina Antikainen and Tuomas Mattila

9.35.1 Introduction

The EURO standards, successful in controlling traditional air pollutants, only regulate the engine use phase emissions. With more diversified engine and fuel choices, the upstream emissions become more and more important. Consequently, a EURO standard type of a regulation model for GHG emissions and fossil fuels seems not functional for all future engine types. A certification system for Best Available Technologies (BAT) in greenhouse gas emission reduction and fuel efficiency in heavy duty vehicles is suggested.

BAT vehicle certification requires that all operating heavy goods vehicles are fitted with BAT in energy efficiency. The aim of the action is to spread good practices and to stimulate technological development.

9.35.2 Assessment

Experience and Feasibility

The US regulatory model requires trucks to be certified by the governmental environment authority. Trucks can be certified if they are fitted with up-to-date energy saving technology (i.e. aerodynamics, low rolling resistance tires and idling control).

The State of California is implementing a similar regulation, requiring all trucks operating within the State are either certified tractors or trailers or retrofitted with energy saving implements. The action is estimated to have a positive impact on freight company profits.

In other industries, BAT has proven to be useful in emission control and dissemination of good practices.

Company/Market Perspective

The most relevant market players affected by this action are:

- Vehicle suppliers +/–
- Technology developers +
- Fleet owners –
- Regulatory certifying bodies +

Reduction Potential

Table 9.34 Reduction potential – BAT vehicle certification for heavy goods vehicles

GHG	+++
FFS	0
Road fatalities	+
Congestion	–

Pro Arguments:

- Good potential for greenhouse gas emission reduction
- Cost-effective, investments have a short payback time
- Better fuel economy reduces other air pollutants
- Provides a stimulus for technology development (guaranteed market)
- Leaves freedom for choosing methods of compliance

Contra Arguments:

- Requires additional supervision authorities
- Aerodynamics may result in longer trucks

Conclusion

The action could speed the adoption of energy efficient technologies in the freight industry. In addition it could stimulate technological development by guaranteeing a market, as has been experienced with the BAT policy in other industries.

Recommended because the action is anticipated to have mainly positive economic impacts and reduce emissions considerably.

9.35.3 Recommended Tasks and Milestones

RTD Policy

- BAT certification stimulates technological progress by guaranteeing a market for technologies which obtain the best available status. This stimulus can result in highly improved energy efficiency through competition between vehicle manufacturers.
- A testing and certifying body would be needed for new technology assessment and for updating the "best available technology" standard.

Transport Policy

- The enforcement of compliance to the certificates would have to be integrated to traffic monitoring.

Milestones

By 2020:

- A testing protocol for new technologies in place.
- The best available level determined for freight transport.
- All new vehicles are required to meet the BAT level.

By 2035:

- BAT standards revised several times.
- All operating trucks meet the certificates.

By 2050:

- Possible replacement of policy if technological progress has slowed down.

9.36 Action 35 – Clean Vehicle Technologies

Julia Düh

9.36.1 Introduction

The analysis of the clean vehicle technologies focuses mainly on low carbon technologies for heavy good vehicles (HGV) in road freight applications (World Economic Forum, 2009).

We identified three main application areas:

- vehicle: improving aerodynamics reducing rolling resistance and alternative power source, like electric engine
- powertrain: engine efficiency, waste heat recovery, alternative powertrains and transmissions
- alternative fuels, e.g. different methods of producing biodiesel.

9.36.2 Assessment

Experience and Feasibility

Reduction in rolling resistance and aerodynamic drag can give a large overall benefit in fuel consumption. For example an averaged HGV 44t gross vehicle weight (GVW) that is on a 1.528 km route over 3 days across UK can achieve a reduction in fuel consumption up to 14% by improving aerodynamic trailers and rolling resistance (Baker et al., 2009).

Some alternative powertrain such as fuel cell may have big potential, but for commercial truck use hydrogen infrastructure has to be implemented.

Company/Market Perspective

The most relevant market players affected by this action are

- Vehicle suppliers +
- Technology developers +
- Fleet owners and hauliers +
- Regulatory certifying bodies +

Reduction Potential

Table 9.35 Reduction potential – clean vehicle technologies

GHG	+++
FFS	+
Road fatalities	0
Congestion	0

Pro Arguments:

- High potential to reduce fuel consumption and CO_2 emissions
- Some aerodynamics applications can be added to existing HGV cab design
- Systems can be reused improving the return on investment (rolling resistance)
- New powertrains, like electric systems have low operating and maintenance costs

Contra Arguments:

- Addition of aerodynamic fairings can add weight and can reduce payload
- Unknown safety impact
- Increasing costs for implementation

Conclusion

There are a lot of technologies for road to reduce GHG. The technologies which have the greatest CO_2 reduction potential are aerodynamic trailers and electric engines. Powertrain technologies which may offer greatest tailpipe CO_2 reduction are fuel cells, full hybrids and electric engines. The benefits are application specific, with significant lifecycle CO_2 impacts depending on the energy mix.

Highly recommended

9.36.3 Recommended Tasks and Milestones

RTD Policy

- Integrated impact assessment for new materials and designs to improve aerodynamics and rolling resistance, including the interaction with infrastructure surface
- Concept for combining aerodynamic applications and applications for rolling resistance for long distance freight transport
- Integrated impact assessment on different propulsion and engine technologies and new biofuels
- Combining different sources for production of 2nd generation biofuels, carbon footprint analysis of new biofuels for long distance freight transport
- Impact assessment of engine efficiency

Demonstration Projects

- Field tests on aerodynamic improvements
- 2015: Demonstration/field trials of different renewable fuels
- 2015–2020: market availability of new biofuels
- Demonstration of different auxiliary fuel cell, electric engines and hybrid systems for LDFT
- Demonstration of CNG compressed natural gas truck engines

Transport Policy

The current legislation constrains the use of aerodynamic implementations at vehicles due to maximum length limits. Requirements of minimum aerodynamics standards and rolling resistance levels for trucks on certain corridors are needed.

Financial support may be given to support the development of sustainable technology for LDFT because technological changes and new technology hide big uncertainties. The implementation of each new technology is influenced by a set of alternatives regarding future energy costs, safety requirements etc.

European Transport Policy

- New directive for maximum weight and length of HGV for necessary aerodynamic changes.
- Setting standards for additional monitoring systems, for e.g. automatic tire pressure adjustment
- For the Europe-wide implementation legislation has to be adapted.

National Transport Policy

- Recommendation for a national production and distribution of infrastructure for biogas/biofuel

Milestones

By 2020:

- Market availability of trucks with aerodynamics and rolling resistance 30% improvements compared to the top performers from 2005.
- Facilitation of improvements in aerodynamics by more flexible directive
- Green corridors are established: field tests for aerodynamic improvements
- Green corridors are established: field test for alternative fuels and alternative engines
- RTD supported a diverse set of alternative fuels; (no competition with food production)
- 8% biofuel share is establishes (10% is biofuel share EU target)

By 2035:

- Market availability of trucks with 50% improvements compared to the top performers from 2005.
- Availability of alternative power technologies for LDFT (electric engines and hybrid systems, etc.)
- The 10% biofuel share EU target is established

By 2050:

- Market availability of trucks with 60% improvements compared to the top performers from 2005.
- More than 15% biofuel share is established

9.37 Side by Side Comparisons

9.37.1 Potential for Reducing GHG Emissions>

Table 9.36 Potential – greenhouse gas emission reduction

	Potential – Greenhouse gas emission reduction						
	−−−	−−	−	0	+	++	+++
1. Investment in ITS							
2. Investment in road infrastructure							
3. Internalization of external costs							
4. HGV weights and dimensions							
5. Liberalization of cabotage							
6. Progressive distance pricing							
7. Different pricing with regards to freight							
8. Harmonized speed limits							
9. Congestion charge							
10. Enforcement of regulations							
11. Investment in rail infrastructure							
12. Freight prioritization							
13. Funding for ERTMS							
14. Electrification of rail corridors							
15. Longer trains							
16. Heavier trains							
17. Investment in IWT infrastructure							
18. Develop new technologies in IWW							
19. Investment in maritime port infrastructure							
20. Training for eco-driving							
21. Automated platooning							
22. Standardized loading units							
23. E-Freight							
24. Network optimization—cargo owner							
25. Network optimization—logistics service provider							
26. CO_2 Labels							
27. Intermodal transport							
28. Transport consolidation and cooperation							
29. Transport route planning and control							
30. Taxation of fossil fuels							
31. Hydrogen infrastructure							
32. Improved batteries							
33. Including CO_2 standards into HGV regulations (EURO6)							
34. BAT vehicle certification for HGV							
35. Clean vehicle technologies							

9.37.2 Potential for Reducing Fossil Fuel Share

Table 9.37 Potential – fossil fuel share reduction

	Potential – Fossil fuel share reduction						
	−−−	−−	−	0	+	++	+++
1. Investment in ITS				■			
2. Investment in road infrastructure				■			
3. Internalization of external costs					■		
4. HGV weights and dimensions			■	■			
5. Liberalization of cabotage				■			
6. Progressive distance pricing					■		
7. Different pricing with regards to freight					■		
8. Harmonized speed limits				■			
9. Congestion charge				■			
10. Enforcement of regulations				■			
11. Investment in rail infrastructure					■		
12. Freight prioritization						■	
13. Funding for ERTMS					■		
14. Electrification of rail corridors						■	
15. Longer trains						■	
16. Heavier trains						■	
17. Investment in IWT infrastructure				■			
18. Develop new technologies in IWW					■		
19. Investment in maritime port infrastructure				■			
20. Training for eco-driving				■			
21. Automated platooning				■			
22. Standardized loading units				■			
23. E-Freight				■			
24. Network optimization – cargo owner				■			
25. Network optimization – logistics service provider				■			
26. CO_2 Labels					■		
27. Intermodal transport						■	
28. Transport consolidation and cooperation				■			
29. Transport route planning and control				■			
30. Taxation of fossil fuels							■
31. Hydrogen infrastructure						■	
32. Improved batteries						■	
33. Including CO_2 standards into HGV regulation (EURO6)				■			
34. BAT vehicle certification for HGV				■			
35. Clean vehicle technologies					■		

9.37.3 Potential for Reducing Road Fatalities

Table 9.38 Potential – road fatalities reduction

	Potential – Road Fatalities reduction						
	−−−	−−	−	0	+	+ +	+ + +
1. Investment in ITS							■
2. Investment in road infrastructure					■		
3. Internalization of external costs				■			
4. HGV weights and dimensions			■	■	■		
5. Liberalization of cabotage					■		
6. Progressive distance pricing				■			
7. Different pricing with regards to freight				■			
8. Harmonized speed limits							■
9. Congestion charge					■		
10. Enforcement of regulations							■
11. Investment in rail infrastructure					■		
12. Freight prioritization				■			
13. Funding for ERTMS					■		
14. Electrification of rail corridors				■			
15. Longer trains				■			
16. Heavier trains				■			
17. Investment in IWT infrastructure					■		
18. Develop new technologies in IWW					■		
19. Investment in maritime port infrastructure					■		
20. Training for eco-driving						■	
21. Automated platooning					■		
22. Standardized loading units				■			
23. E-Freight					■		
24. Network optimization – cargo owner					■		
25. Network optimization – logistics service provider					■		
26. CO_2 Labels				■			
27. Intermodal transport					■		
28. Transport consolidation and cooperation				■			
29. Transport route planning and control					■		
30. Taxation of fossil fuels					■		
31. Hydrogen infrastructure			■	■			
32. Improved batteries					■		
33. Including CO_2 standards into HGV regulation (EURO6)				■			
34. BAT vehicle certification for HGV					■		
35. Clean vehicle technologies				■			

9.37.4 Potential for Reducing Congestion

Table 9.39 Potential – congestion reduction

	Potential – Congestion reduction						
	– – –	– –	–	0	+	+ +	+ + +
1. Investment in ITS							■
2. Investment in road infrastructure						■	
3. Internalization of external costs					■		
4. HGV weights and dimensions					■		
5. Liberalization of cabotage					■		
6. Progressive distance pricing					■		
7. Different pricing with regards to freight					■		
8. Harmonized speed limits					■		
9. Congestion charge							■
10. Enforcement of regulations						■	
11. Investment in rail infrastructure					■		
12. Freight prioritization						■	
13. Funding for ERTMS					■		
14. Electrification of rail corridors					■		
15. Longer trains					■		
16. Heavier trains					■		
17. Investment in IWT infrastructure						■	
18. Develop new technologies in IWW					■		
19. Investment in maritime port infrastructure						■	
20. Training for eco-driving					■		
21. Automated platooning					■		
22. Standardized loading units				■			
23. E-Freight				■			
24. Network optimization—cargo owner						■	
25. Network optimization—logistics service provider						■	
26. CO_2 Labels					■		
27. Intermodal transport					■		
28. Transport consolidation and cooperation					■		
29. Transport route planning and control					■		
30. Taxation of fossil fuels					■		
31. Hydrogen infrastructure				■			
32. Improved batteries				■			
33. Including CO_2 standards into HGV regulation (EURO6)				■			
34. BAT vehicle certification for HGV			■				
35. Clean vehicle technologies				■			

9.37.5 Recommendation

Table 9.40 Recommendation

	Not recommended	Recommended	Highly recommended
1. Investment in ITS			
2. Investment in road infrastructure			
3. Internalization of external costs			
4. HGV weights and dimensions			
5. Liberalization of cabotage			
6. Progressive distance pricing			
7. Different pricing with regards to freight			
8. Harmonized speed limits			
9. Congestion charge			
10. Enforcement of regulations			
11. Investment in rail infrastructure			
12. Freight prioritization			
13. Funding for ERTMS			
14. Electrification of rail corridors			
15. Longer trains			
16. Heavier trains			
17. Investment in IWT infrastructure			
18. Develop new technologies in IWW			
19. Investment in maritime port infrastructure			
20. Training for eco-driving			
21. Automated platooning			
22. Standardized loading units			
23. E-Freight			
24. Network optimization—cargo owner			
25. Network optimization—logistics service provider			
26. CO_2 Labels			
27. Intermodal transport			
28. Transport consolidation and cooperation			
29. Transport route planning and control			
30. Taxation of fossil fuels			
31. Hydrogen infrastructure			
32. Improved batteries			
33. Including CO_2 standards into HGV regulation (EURO6)			
34. BAT vehicle certification for HGV			
35. Clean vehicle technologies			

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10 Action Plan and Conclusions

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Abstract The action plan aims to reach a sustainable transport system, by reaching the defined scenario. The FREIGHTVISION scenario consists of a certain development of key characteristics. According to FREIGHTVISION's conceptual framework, the action plan therefore intends to influence and determine the development of the key characteristics. In this chapter the action plan is presented and the policy recommendations, which are the final project results.

10.1 Introduction

The FREIGHTVISION action plan aims to reach a sustainable transport system, by reaching the defined scenario. The FREIGHTVISION scenario (see Chap. 8) consists of a certain development of key characteristics. According to FREIGHTVISION's conceptual framework, policy actions should therefore intend to influence and determine the development of the key characteristics. The policy actions are therefore finally evaluated according to their impact on the key characteristics, and not on the sustainability criteria. (see link 3 Fig. 10.1). This was done by selecting for each key characteristic, the most effective policy actions.

Within FREIGHTVISION 35 policy actions to influence the freight transport system were identified and analyzed. This exercise included two different policy areas were combined which are synergetic, but mostly treated separately: research (RTD) and transport policy. The reason why these aspects are usually not discussed together is to a certain amount organizational. Different Member States' ministries or departments are usually in charge for these two policy areas. In addition also the staff in the ministries has different backgrounds, as RTD people have usually a technology background, while transport ministries' staff has mainly a juristic education. Nevertheless these areas are here combined as the challenges that are much demanding that they cannot be met only by one of the two areas. Therefore an integrated approach has been applied combining the development of new technologies with relevant policy criteria. With this approach

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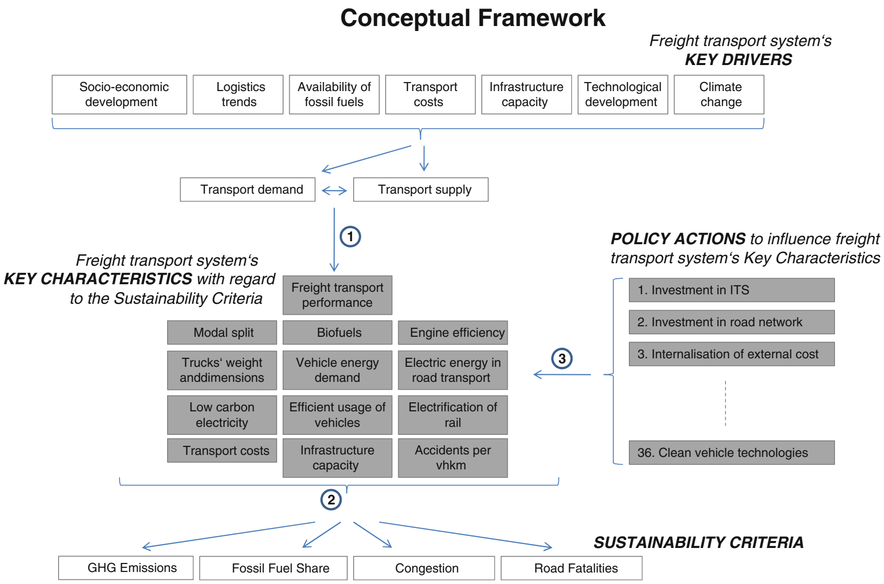

Fig. 10.1 Conceptual framework used for the assessment of policy actions

the following options are available: When an appropriate technology is developed, the policy criteria can set the right framework for the market, so the price and other signals from the market will be a driving force for the fast introduction of the innovative technologies. Furthermore policy criteria can provide incentives for the faster development of innovative technologies necessary to meet the challenges of the long-distance freight transport sector. The core objective of this approach is therefore to develop an action plan combining the RTD and transport policy in an optimal way.

The action plan is a combination of RTD and transport policy tasks for each of the most effective policy actions with regard to the individual key characteristics. The action plan was developed in the following two steps:

- Selection of the most effective policy actions.
- Identification of tasks for the selected policy actions.

10.2 Selection of Policy Actions

The starting point for the selection of the most effective policy actions for each key characteristic was the list of the 35 actions, which were analysed before. For each key characteristic, it was discussed within the project team which policy action would be most effective. The discussions lead to the following selection:

Table 10.1 Key characteristics and most effective policy actions

Key characteristics	Most effective policy actions
Transport performance	Network optimization cargo owner E-freight Transport route planning and control
Vehicle energy demand	Clean vehicle technologies I – Aerodynamics and rolling resistance Best available technologies
Low carbon electricity	CO_2 labelling Taxation of fossil fuels
Electric energy in road transport	Improved batteries Taxation of fossil fuels Investment in road infrastructure
Biofuels	Clean vehicle technologies II – biofuels Taxation of fossil fuels
Efficient usage of vehicles	Transport consolidation and cooperation Training for eco-driving Liberalization of cabotage
Engine efficiency	Including CO_2 standards into HGV regulations Best available technologies
Modal split	ERTMS Intermodal transport Internalization of external cost
Electrification of rail	Electrification of rail corridors CO_2 labelling Taxation of fossil fuels
Trucks weight & dimensions	Modifying the rules for HGV's weights and dimensions Investment in road infrastructure
Infrastructure capacity	Investment in ITS Investment in road infrastructure
Transport costs	Internalization of external costs Congestion charge
Fatalities per vhkm	Investment in ITS Harmonized speed limits Training for eco-driving Enforcement of regulations

Due to this analysis the following policy actions are not the most effective ones with regard to the scenario and thus are not part of the action plan:

- Investment in rail infrastructure
- Freight prioritization
- Longer trains
- Heavier trains
- Investment in IWT infrastructure
- Develop new technologies in IWW
- Investment in maritime port infrastructure
- Automated platooning
- Hydrogen infrastructure

10.3 Identification of Tasks

In the next step for each key characteristic–policy action combination the most relevant tasks were identified. The tasks contain RTD and transport policy aspects and some of them also milestones. Following is an analysis of the potential tasks for each key characteristic:

Transport Performance

Transport performance can be influenced by the cargo owners and logistics service providers as their decisions on supply chains, manufacturing locations and warehouse locations influence transport demand. Policy can try to influence these private decisions by increasing transport cost (e.g. internalization of external costs) or soft factors like the introducing of CO_2 labels. When source and destination of the transport is defined, only the routes chosen can be influenced. This could be done by improving the information available to the transport system users, and can be used to influence transport planning.

Vehicle Energy Demand

Vehicle energy demand is mainly driven by the aerodynamics, the materials and rolling resistance. There seem to be improvements possible both from RTD policy and transport policy. RTD policy could emphasize the research in new materials, aerodynamics and rolling resistance. Transport policy should take care that the technologies are used. This can be done by defining maximum aerodynamics and rolling resistance levels on certain corridors, adapting the weight and dimension directive to allow for new aerodynamic applications, establishing a certifying body for technology assessment and integrating the enforcement of the compliance to the certificates into traffic monitoring.

Low Carbon Electricity

The upstream emissions of electricity can only be indirectly influenced by RTD and transport policy. Approaches for influencing it from a transport policy are CO_2 labelling of transport services including upstream emissions and taxation of fossil energy, which should be taxed equally. The tax should depend on the GHG emissions, but not whether it is used upstream or downstream. The effects of an adopted carbon tax based on Emission Trading Scheme on the truck market, modal split and GHG emissions have to be investigated.

Electric Energy in Road Transport

The main obstacles for usage of electric energy in road transport are cost, and weight of the batteries. It is therefore main importance to increase RTD funding for new technologies. From transport policy the diffusion could be supported by taxation of fossil fuels, but also by electric infrastructure investments (e.g. charging stations) on corridors. A key demonstration project[1] about an electric Green Corridor could stimulate the development in both passenger and freight transport.

Biofuels

The main issues with regard to biofuels are due to the production process and cost. For upstream emissions, standards should be defined, but also other impacts have to be considered like other environmental impacts (e.g. water and biodiversity) and socio-economic impacts (e.g. food price). If standards are met, market competitiveness with fossil fuels has to be ensured by an appropriate taxation system.

Efficient Usage of Vehicles

Usage of vehicles in road transport is inefficient mainly due to driver behaviour and loading factors. Driving behaviour could be enhanced by introducing technologies (e.g. eco-metres), training and incentive schemes for drivers. This could be done on a Member States level, but a harmonized implementation of these approaches by the EU would be favourable. Loading Factors could be increased by increasing vhkm cost and liberalization of cabotage. A fully liberalization should be reached within the next decade.

1 Key Demonstration Projects are large demonstration projects on national or European level to show and evaluate the possibilities and push behavioral and technological changes. Key demonstration projects are related to corridors and are based on business models and combine the innovative technologies with a relevant regulatory framework.

Engine Efficiency

Engine efficiency can be increased by including CO_2 standards into HGV regulations and by usage of best available technologies. The right mix of 'carrots' (financial support for the technological development and acquisition of advanced vehicles) and sticks (enforcement of usage of best available technologies) will lead to increased engine efficiency.

Modal Split

Modal shift to rail and IWW can be reached by an improved infrastructure capacity management, the support of intermodal transport, and the harmonization of policies in all modes with regard to external cost. To improve capacity management in rail, ERTMS should be introduced on main lines by 2020 and on secondary lines by 2035. Intermodal transport can be supported with European and national funding schemes. In addition the development and deployment of e-freight would remove existing barriers for intermodal transport.

Electrification of Rail

A uniform electrification system in Europe would be desirable, but needs additional research. Additional policy actions supporting the trend to electrification of rail are CO_2 labelling and taxation of fossil fuels.

Truck Weight and Dimension

Additional safety requirements may be needed, if new rules for truck weight and dimensions are introduced. A core network for EMS could be established, but will require investment in road infrastructure.

Infrastructure Capacity

Infrastructure capacity can be increased by investment in ITS and investment road infrastructure. With regard to ITS temporary hard shoulder usage near and at bottlenecks, the provision of real time information on bottlenecks and the detection of dysfunctional vehicles are recommended. With regard to road infrastructure, the focus

should not be on building new infrastructure, but on research on the better usage of the existing infrastructure.

Transport Cost

If policy wants to avoid congestion, transport costs have to be increased. Approaches are the introduction of a congestion charge to distribute the traffic or an internalization of external costs.

Fatalities per Truck km

The number of fatalities can be reduced by investment in ITS, harmonization of speed limits, training and enforcement of regulations. With regard to ITS cooperative assistance systems (research and widespread application), product liability and legal requirements for some safety systems are recommended. Speed limits should be harmonized on critical roads. Training and also legal obligations for defensive driving should be introduced. Finally the regulations should be enforced with more automatic control systems (weight, weight distribution, rest time, speed).

As can be seen policy has many options to influence the key characteristics. Each of the tasks can be applied in a stricter or not so strict way, and can thus adapted when needed or other information comes available about developments of another key characteristic.

Due to this flexibility, the action plan is also robust and adaptive. Robust means that the action plan is effective in different plausible futures. Adaptive means that the action plan can be adapted in the future if needed, and there is new information available.

10.4 Policy Recommendation

The main project's result is a policy recommendation, which consists of three parts.

- Part one is a recommendation for a vision, i.e. on quantitative reduction targets to be politically agreed for the four sustainability criteria until 2020, 2035 and 2050.
- Part two is a recommendation to focus on specific key characteristics, which will be crucial whether or not the vision will be reached. Based on modelling, results goals and a prioritization are proposed for the key characteristics.
- Part three is a recommendation for RTD and transport policy actions to shape the key characteristics into the right direction. The most effective actions for each key characteristic are proposed forming the action plan.

10.4.1 Recommendation 1: Vision

The first recommendation is to get a political agreement on European vision for a sustainable long-distance freight transport. It is important to define quantitative targets for each of the four sustainability criteria. These quantitative targets should be ambitious, but feasible, and also contain intermediate targets for the time horizons 2020 and 2035 (see Table 10.2).

This vision is very challenging, but according to the analysis it should be reachable. At the beginning of the FORESIGHT process, some stakeholders thought these goals are too ambitious, but at the end of the process there was a very high consensus about the feasibility of the vision.

This vision is based on the definition of the indicators. The indicators for GHG emissions, fossil fuel share, road fatalities and congestion were precisely defined. It is important to stress that by defining the indicators also the system boundaries are set, and thus aspects out of the boundaries are not addressed within the vision, and all the consecutive steps like the identification of the key characteristics and the action plan. Every boundary has advantages and disadvantages. If different definitions for the indicators were used, of course the numbers would have to be adapted.

Table 10.2 Vision for reducing GHG emissions, fossil fuel share, congestion and road fatalities

	2020	2035	2050
GHG emissions (compared to 2005)	−20%	−70%	−80%
Fossil fuel share (reduction to this level)	80%	60%	40%
Congestion (compared to 2005)	−17%	−33%	−50%
Road fatalities (compared to 2005)	−40%	−65%	−80%

10.4.2 Recommendation 2: Prioritization of the Key Characteristics and their Targets

The second recommendation is to focus the policy on the development of certain key characteristics and to prioritize them. By shaping these key characteristics by political means, the vision should be possible to be reached. This recommendation is based on modelling results.

The goal of the backcasting process was to identify the most important key characteristics for reaching the vision defined. Then for each key characteristic, realistic quantitative targets for 2020, 2035 and 2050 were identified. If all targets are met, then according to the models the vision will be reached. Based on these targets, the key characteristics were prioritized. The prioritization is based on the relevance of each key characteristic–Target combination for reaching the vision. Below is the list of the key characteristics, their priority and their targets for reaching the GHG emissions and fossil fuel share vision:

Table 10.3 Key characteristics – prioritization and targets for reducing GHG emissions and fossil fuel share

Key characteristic	Priority	Target[2] for Year		
		2020	2035	2050
Transport performance (Max. increase of tkm)	1.	+30%	+43%	+44%
Vehicle energy demand (reducing)	2.	−20%	−40%	−50%
Low carbon emissions (reducing carbon emissions in electricity production)	3.	−37.5%	−61%	−88%
Electric energy in road transport	4.	0%	10%	25%
Biofuels – share	5.	8%	24%	33%
Biofuels – upstream emissions		−35%	−83%	−83%
Efficient usage of vehicles	6.	+8%	+30%	+50%
Engine efficiency	7.	+21%	+40%	+45%
Modal split	8.	Road 75% Rail 19% IWW 6%	Road 70% Rail 22,5% IWW 7.5%	Road 65% Rail 25% IWW 10%
Electrification of rail	9.	66%	75%	80%
Truck weight and dimension (market share of gigaliners in tkm)	10.	2%	8%	10%

In addition to the above list the following key characteristics are relevant for reducing congestion (Due to the low number of key characteristics, no prioritization was given):

Table 10.4 Key characteristics – targets for reducing congestion

Key characteristics	Target for year		
	2020	2035	2050
Infrastructure capacity (vhkm)	+10%	+20%	+30%
Price per vhkm	+25%	+50%	+50%

2 Values with "+" or "−" are related to 2005; when there is neither a "−" nor a "+" the value is a percentage of market penetration; all values should be reached at least by this level.

In addition to the above list the following key characteristics are relevant for reducing road fatalities:

Table 10.5 Key characteristic – targets for reducing road fatalities

Key characteristic	Target for		
	2020	2035	2050
Reduced fatalities per truck vhkm	−15%	−35%	−60%

The tables above are based only on the sustainability criteria analyzed in this project. If other criteria like economic criteria or other environmental criteria were considered, the prioritization might differ. It has also to be mentioned that there was no economic analysis performed within the project. The reason is that the project team assumed that it would have been out of the scale to do it within the given time horizon. This aspect might be useful to look at in another project.

In addition it has to be mentioned that the selection of figures for the quantitative targets is subjective, and there are infinite other combinations of targets imaginable, where also the vision could be reached. For sure each interest group would set the targets differently according to their economic goals. The project's goal was to be as objective as possible and it is considered by the project team as a good starting point for political discussions.

10.4.3 Recommendation 3: Action Plan – Shaping the Key Characteristics

The third recommendation is to focus policy actions on shaping the key characteristics. This bundle of actions combines RTD and transport policy actions.

The project team developed 36 actions from the areas of road transport, rail transport, IWW and maritime transport, supply chain, energy suppliers and vehicle suppliers. These actions were analyzed to get an overview about their pros and cons, RTD and transport policy aspects, possible milestones, and technical, economic and political feasibility. Then the most promising actions for each key characteristic were identified. Below is the list of the most effective actions for each key characteristic and related tasks.

Table 10.6 Action plan – key characteristics, policy actions and tasks

Key characteristics	Policy actions	Tasks
Freight transport performance	Network optimization cargo owner	• No direct transport or RTD policy, but many other policy actions have an indirect impact (Internalization of external costs, CO_2 labelling);

Table 10.6 (*continued*)

Key characteristics	Policy actions	Tasks
	Network optimization logistics service provider	• No direct transport or RTD policy, but many other policy actions have an indirect impact (internalization of external costs, CO_2 labelling);
	Transport route planning and control	• Improving software solutions in order to display available real-time data on problem links, and integration of planning and control software to influence transport planning; should be finished until 2020;
Vehicle energy demand	Clean vehicle technologies I – aerodynamics and rolling resistance	• Emphasis on research in new materials, aerodynamic design and rolling resistance; • Requirement of maximum aerodynamics and rolling resistance levels for trucks on certain corridors; • Adaption of weight and dimension directive to allow for new aerodynamics applications;
	Best available technologies	• A testing and certifying body is established for technology assessment and for updating the best available technology; • Enforcement of compliance to the certificates is integrated into traffic monitoring;
Low carbon electricity	CO_2 labelling	• The methodology to calculate a product's carbon footprint has to be standardized (EU-wide or even global level; e.g. ISO Standard) and implemented in integrated information systems;
	Taxation of fossil fuels	• Upstream and downstream equal taxation system dependent on GHG emissions; • EU transport policy adopts to EU climate policy targets and increases fuel taxes according to the quantitative agreements on GHG emissions;

Table 10.6 (*continued*)

Key characteristics	Policy actions	Tasks
		• Research on the effects of carbon tax and new truck market, modal split and CO_2 emissions of truck fleets will be needed;
Electric energy in road transport	Improved batteries	• Funding for electric infrastructure; synergy with the electrification of passenger transport; • Gradual electrification beginning with auxiliary power and continuing with the lengthening of battery powered operation distance when new battery materials become commercially feasible;
	Taxation of fossil fuels	• EU transport policy adopts to EU climate policy targets and increases fuel taxes according to the quantitative agreements on GHG Emissions; • Research on the effects of carbon tax on modal split and carbon emissions of truck fleets;
	Investment in road infrastructure	• RTD on integration of energy and transport network; • Demonstration project on "Electrified Green Corridor"; • TEN funding primarily for "greening" the TEN network;
Biofuels	Clean vehicle technologies II – biofuels	• Setting standards for upstream emissions; • Impact assessment, footprint analysis and establishment of new biofuels for LDFT;
	Taxation of fossil fuels	• EU transport policy adopts to EU climate policy targets and measures adopted under a quantitative agreement of CO_2 emissions; • Research on the effects of carbon tax and new truck market, modal split and CO_2 emissions of truck fleets;
Efficient usage of vehicles	Transport consolidation and cooperation	• Improvements in order to provide data-security for competing companies which merge their transports have to be achieved;

Table 10.6 (*continued*)

Key characteristics	Policy actions	Tasks
		• Charging empty runs or even not fully loaded trucks;
	Training for eco-driving	• Technology for improving eco-driving, e.g. eco-meters defensive driving, driving technique, incentive schemes for drivers; • Coordination and harmonization of the implementation by EU; • A directive including defensive driving developed & implemented;
	Liberalization of Cabotage	• Fully liberalized within the European union until 2020;
Engine efficiency	Including CO_2 standards into HGV regulations	• Support on technological development (especially engine efficiency, aerodynamics, rolling resistance) is needed;
		• Financial support (e.g. lower taxes or congestion charges) to promote technological development and to support acquisition of advanced vehicles;
	Best available technologies	• A testing and certifying body is established for technology assessment and for updating the best available technology; • Enforcement of compliance to the certificates is integrated into traffic monitoring;
Modal split	ERTMS	• By 2020 ERTMS implementation at main lines and equipment (about 4,000 locos); • By 2035 main lines and secondary lines are equipped with ERTMS (equipment and tracks);
	Intermodal transport	• The Marco Polo, the TEN programmes, and member states' national funding programmes are strengthened; • Research on IT interfaces/links as well as the automation of transhipments; • By 2020 50%, by 2035 75% and by 2050 90% of sea container transport over 500 km is by rail or IWW.

Table 10.6 (*continued*)

Key characteristics	Policy actions	Tasks
	Internalization of external cost	• Harmonization of policies in all modes of transport using the same criteria (with a particular focus on the measurement of external effects and a common system of determining the costs attributed to them);
	E-freight	• Development and deployment of an e-freight platform serving as a multi-modal communication system for freight forwarders, service providers and infrastructure providers; operational by 2020;
Electrification of rail	Electrification of rail corridors	• Research has to be done concerning uniform electrification systems and/or multisystem locomotives;
	CO_2 labelling	• The methodology to calculate a product's carbon footprint is standardized (EU-wide or even global level; e.g. ISO Standard) and implemented in integrated information systems;
	Taxation of fossil fuels	• EU transport policy adopts to EU climate policy targets and measures adopted under a quantitative agreement of CO_2 emissions; • Research on the effects of carbon tax and new truck market, modal split and CO_2 emissions of truck fleets;
Truck weight and dimension	Modifying the rules for HGV's weights and dimensions	• Additional safety requirements may be imposed.
	Investment in road infrastructure	• A core network for EMS is established;
Infrastructure capacity	Investment in ITS	• Providing funding and applying temporary hard shoulder usage near and at bottlenecks; • Provision of information to users of transport; • Research on the detection dysfunctional vehicles;

Table 10.6 (*continued*)

Key characteristics	Policy actions	Tasks
	Investment in road infrastructure	• Research in reduction and elimination of different bottlenecks, e.g. by introducing ITS; • Research in better usage of existing transport infrastructure;
Transport costs	Internalization of external cost	• Harmonization of policies in all modes of transport using the same criteria (with a particular focus on the measurement of external effects and a common system of determining the costs attributed to them);
	Congestion charge	• Develop and establish a rational concept to avoid congestion, i.e. aim at a distribution of traffic that keeps users of infrastructure moving;
Accidents per truck-vhkm	Investment in ITS	• Research in innovative cooperative assistance systems and their widespread application; • Solving product liability which would permit a higher degree of automatisation; • Legal requirement for some safety systems on HGV;
	Harmonized speed limits	• On national level an action plan for implementing the harmonization of speed limits on critical roads;
	Training for eco-driving	• Technology for improving eco-driving, e.g. eco-meters defensive driving, driving technique, incentive schemes for drivers; • Coordination and harmonization of the implementation by EU; • A directive including defensive driving should be developed & implemented;
	Enforcement of regulations	• New technology and more automatic control systems, e.g. speed, rest time, weight and weight distribution; • Co-ordination of the enforcement focus areas to ensure traffic safety;

10.5 Conclusions and Outlook

The project ended at an interesting point in time when new European Commissioners were appointed and the Commission was preparing the new European White Paper on transport and mobility. It can be assumed that the project's results will be used as an input for the White Paper, due to the very positive feedback from the Commission's representatives about the project's results, when the project's recommendations were presented at the project's Final Conference in Brussels.

Due to this political sensitive point in time some stakeholders, especially from the rail sector and non-governmental organisations, did not agree with the recommendations. On the other hand representatives of the road sector were satisfied with the project's conclusion, because they considered the project's results very positive for them.

This is a big misunderstanding of the project's approach and results: the recommendations are neither pro nor against road transport; however the sustainability problems are mainly due to road transport and will have to be solved mainly there. To make it short: policy will fail to get a sustainable freight transport system, if the focus on improvements is not given on road transport. This focus will not be only favourable for road transport as focusing means increasing the pressure on reaching a sustainable road transport system. The discussions with the stakeholders showed that road stakeholders do understand that their system will have to be improved, but they just want to make sure that there will be an acceptable mixture of carrots and sticks implemented enabling a smooth development of the road transport system.

The impact on the rail and inland waterways transport system is hard to predict. If road transport succeeds in reaching the goals defined in the vision of the project, and thus will become increasingly more sustainable and in addition will be able to keep its economic competitive edge, then alternative transport modes will have hard times to increase their market share and also to give reasons for public infrastructure investments. So there is a high risk especially for rail transport with these future developments involved. On the other hand there will be a big chance, if road transport cannot keep with the recommended improvements. But this chance can only be utilized, if clear targets are set and consequences are defined both for the road and rail system. So in the project team's opinion the action plan, as being based on clear improvement targets, provides challenges for rail transport.

Outlook

No project can cover everything. The projects limitations and weaknesses are especially that

- only four transport-oriented sustainability criteria were addressed. Many more might be interesting to look at, like economic and social aspects. If other criteria were considered, the recommendation might differ.
- No economic assessment was carried out like a cost-benefit analysis (CBA). The main reason is that time-horizons of 20 up to 40 years involve so many uncertainties and that it was out of the financial and time scale of the project.

The main criticisms on the project results were the lack of vision and overestimate of possible improvements in road transport. This might be true – we should know in 40 years.

FREIGHTVISION has developed targets for sustainable European freight transport for 2050. Within the project respective actions were designed and assessed which would help to reach these targets. These actions and the resulting action plan define and provide opportunities for sustainable European freight transport. It will be up to the public and private stakeholders to recognize and implement these chances respecting the ecological, economic and social needs of transport. – "Alles ist entzaubert, der Zauber beginnt von neuem."[3]

3 "Everything is disenchanted – the enchantment starts over again ...", Monika Czernin, „Duino, Rilke und die Duineser Elegien".Dtv München 2004.

Appendix A
Abbreviations

21st CTP	21st Century Truck Partnership
3PL	Third party logistics
ACC	Adaptive cruise control
ADT	Average daily traffic
AIS	Automatic identification system
AMP	Alternative marine power
ANG	Adsorbed natural gas
APS	Advanced planning system
APU	Auxiliary power unit
ASC	Automatic stacking cranes
ATP	Automatic train protection system
ATP	Available-to-promise
AVI	Automatic vehicle identification
AVL	Automatic vehicle location
BAT	Best available technology
BAU	Business as usual
bbl	Barrel
BMEP	Break mean effective pressure
bn	billion
BPR	Bureau of public roads (volume-delay equation)
BSFC	Break specific fuel consumption
BtL	Biomass-to-liquid
C2C	Car-to-car-communication
CAFE	Clean air for Europe
CARE	Community database on road fatalities on the roads in Europe
CBD	Convention on biological diversity
CCS	Carbon capture and storage
CI	Compression ignition
CIS	Commonwealth of independent states
CNG	Compressed natural gas
CO	Carbon monoxide
CO2	Carbon dioxide
CT	Combined transport
CTG	Combined transport group
CtL	Coal to liquid

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DAB	Digital audio broadcasting
dB	Decibel
DC	Direct current
DCCS	Dilution controlled combustion system
DG	Directorate general
DG MOVE	Directorate-general mobility and transport
DG TREN	Directorate-general transport and energy
DIAD	Delivery information acquisition device
DME	Dimethyl ether
DMI	Driver machine interface
DMS	Dynamic message sign
DOE	Department of Energy (US)
DPF	Diesel particle filter
DWT	Deadweight tonnage
EAP	Environment action programme
EC	European Commission
ECE	Economic Commission for Europe
ECR	Efficient consumer response
EDI	Electronic data interchanges
EEA	European Environmental Agency
EEV	Enhanced environmentally friendly vehicle
EGNOS	European Geostationary Navigation Overlay Service
EGR	Exhaust gas recirculation
EIA	Energy information administration
EILU	European intermodal loading unit
EMU	European economic and Monetary Union
EPA	Environmental Protection Agency (US)
EPR	European performance regime
ERA	European Railway Agency
ERANET	European research area networks
ERP	Enterprise resource Planning
ERSO	European Road Safety Observatory
ERTMS	European rail traffic management system
ESC	Electronic stability control
ETBE	Ethyl tertiary butyl ether
ETCS	European train control system
ETS	Emission trading scheme
ETX	Electronic toll express
EU	European Union
FCD	Floating car data
FCVs	Fuel cell vehicles
GATT	General agreement on tariffs and trade
GCI	Global commerce initiative
GDP	Gross domestic product
GHG	Greenhouse gas

GNSS	Global navigation satellite system
GPS	Global positioning system
GTL	Gas-to-liquid
GVA	Gross value added
GVW	Gross vehicle weight
H2	Hydrogen
HAM	Humid air motor
HC	Hydrocarbons
HCCI	Homogeneous charge compression ignition
HCLI H	Homogeneous charge late injection
HD	Heavy duty
HFC	Hydrofluorocarbon
HFO	Heavy fuel oil
HGV	Heavy goods vehicles
HPLI	Highly premixed late injection
HTSC	High temperature super conductor
HTX	Electronic toll express
HVAC	Heating, ventilating and air conditioning
HVO	Hydrogenated vegetable oil
Hz	Hertz
ICE	Internal combustion engine
ICT	Information and communications technology
IEA	International Energy Agency
IFT	Intermodal freight terminals
IGBT	Insulated gate bipolar transistors
IM	Infrastructure manager
IMO	International Maritime Organization
IMT	Intermodal transport
IPCC	Intergovernmental panel on climate change
ISO	International Organization for Standardization
IT	Information technology
ITS	Intelligent transport systems
ITT	Inter terminal transport
IWT	Inland waterway transport
IWW	Inland water ways
LDFT	Long distance freight transport
LDV	Light duty vehicles
LDW	Lane departure warning
LH2	Liquid hydrogen
LHV	Long and heavy vehicle
LHV	Long heavy goods vehicles
LNG	Liquefied natural gas
LNT	Lean NOX trap
Lo/Lo	Lift on / Lift off
LOS	Level of service

LP	Linear programme
LPG	Liquefied petroleum gas
LSF	Low sulphur fuel
LTC	Low temperature combustion
MCFC	Molten carbonate fuel cell
MDO	Marine diesel oil
MGO	Marine gasoil
MIP	Mixed integer programme
MoS	Motorways of the Sea
MP	Master planning
MPG	Miles per gallon
MTS	Multi trailer systems
NAFTA	North American Free Trade Agreement
NEC	National emissions ceiling
OECD	Organisation for Economic Co-operation and Development
PFC	Perfluorocarbons
PM	Particulate matter
ppm	Parts per million
RDS	Radio data system
RF	Radio frequency
RFID	Radio frequency identification
RIS	River information system
Ro/Ro	Roll on / Roll off
rpm	Revolutions per minute
RSC	Rail service centre
RTD	Research and technology development
RU	Railway undertakings
SaaS	Software as a service
SC	Supercharged (engine)
SCM	Supply chain management
SCR	Selective catalytic reduction
SI	Spark-ignition
SME	Small and medium enterprises
SNP	Strategic network planning
SOFC	Solid oxide fuel cell
SOX	Sulphur oxides
SSS	Short sea shipping
SWATH	Small waterplane area twin hull
TAF	Telematic applications for freight
TC	Turbocompound
TCC	Traffic control center
TEM	Thermoelectrical module
TEN-T	Trans-European transport network
TERM	Transport and environment reporting mechanism of European Commission

TEU	Twenty-foot equivalent unit
tkm	tonne km
TMC	Traffic message channel
TMS	Transport management system
TPEG	Transport Protocol Expert Group
TSI	Technical specifications for interoperability
UIC	Union Internationale de Chemins de fer (International union of railways)
ULCC	Ultra large crude carrier
ULCV	Ultra large container vessel
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
US EPA	United States Environmental Protection Agency
vhkm	vehicle km
VLBC	Very large bulk carrier
VLCC	Very large crude carrier
VMS	Variable Message Signs
VOC	Volatile organic compound
VTG	Variable turbine geometry
VTMIS	Vessel traffic management and information systems
VTT	Technical Research Centre of Finland
WBCSD	World Business Council for Sustainable Development
WEC	World Energy Council
WEO	World Energy Outlook
WHO	World Health Organisation
WIM	Weigh-in-motion
WP	Work package
WTO	World Trade Organization
xFCD	Extended floating car data

Appendix B
List of Stakeholders

Below is a list of the stakeholders, who attended at least one FREIGHTVISION Forum Meeting. The number in the third column indicates to which FREIGHTVISION Forum Meeting the stakeholder attended.

Tom Antonissen	F&L, Freight & Logistics Leaders' Forum	4
Özgül Ardic	CER, Community of European Railway and Infrastructure Companies	4
Rainer Aust	ERTRAC, European Road Transport Research Advisory Council (DE)	1
Stefan Back	SIFA, Swedish International Freight Association (SE)	1, 2, 3, 4
Jeannie Beckett	The Beckett Group (US)	3
Rob Bekking	DB Schenker (DE)	1, 2, 4
Alan Bennett	Rail Freight Group (UK)	1, 2
Joseph Beretta	PSA Peugeot-Citroën (FR)	1, 2
John Berry	DG TREN, EC (EU)	1, 2, 3, 4
Matthieu Bertrand	F&L, Freight & Logistics Leaders' Forum	4
Niels Beuck	CLECAT, European Association for Forwarding, Transport, Logistics, Customs	3, 4
Marc Billiet	IRU, International Road Transport Union (BE)	1, 3, 4
Wolfgang Bohrer	DB Netz AG (DE)	1, 2, 4
Corinna Bonati	Deutsche Bahn AG (BE)	3, 4
Klaus Bonhoff	NOW, National Organisation Hydrogen and Fuel Cell Technology (DE)	1, 3
Henryk Brauer	T & E, Transport & Environment	3
Michael Browne	Univ. of Westminster (UK)	1, 2, 3
Martin Burkhardt	UIRR, International Union of combined Road-Rail transport companies (BE)	2, 3, 4
Gabriela Caraman	F&L, Freight & Logistics Leaders Forum	3
Francesco Carbone	EIA, European Intermodal Association	4
Lola Cardenas	ECG, The Association of European Vehicle Logistics	3, 4
Michael W Cech	OMV (AT)	2, 3, 4
Myriam Chaffart	ETF, European Transport Workers Federation (BE)	1, 2, 3
Lucie Charouskova	EU-Commission, DG TREN	3
Chris Chopyak	Alchemy	2
Michael Clausecker	UNIFE, Association of the European Rail Industry	2

Karin de Boo	Port of Rotterdam (NL)	1
Arend de Jong	Air France KLM Cargo (NL)	1
Jacques Dirand	CER, Community of European Railway and Infrastructure Companies	2, 3, 4
Lizzie Diss	Department for Transport (UK)	2
Guillaume Dufrosne	CLECAT, European Association for Forwarding, Transport, Logistics, Customs	2
Walter Edinger	Wiener Hafen Group (AT)	1, 2
Mario Eland	EuroAirport Basel (FR)	1, 2
Karoline Entacher	WKÖ, Austrian Federal Economic Chamber (AT)	4
Arkos Ersek	UIRR, International Union of combined Road-Rail transport companies (BE)	4
Irene Feige	IFMO, Institute for Mobility Research (DE)	1, 2, 3
Eric Feyen	UIRR, International Union of combined Road-Rail transport companies (BE)	1
Fleur Fragola	SNCF	2, 3, 4
Otto Frommelt	Volvo Austria GmbH (AT)	1, 2, 3, 4
Irene Fusco	IRF-BPC, International Road Federation (BE)	1, 2, 3, 4
Gavin Gaunt	Dep. for Transport (UK)	1
Simon Godwin	Daimler AG	2
Michael Grubmann	WKÖ, Austria Federal Economic Chamber	2
Inger Gustafsson	ERANET	2, 3, 4
Theresia Hacksteiner	EBU, European Barge Union (NL)	1, 2
Nikolaus Hartig	ECR, Efficient Customer Response Austria (AT)	1, 4
Elisabeth Heid	UIRR, International Union of combined Road-Rail transport companies (BE)	1
Marlene Hennicke	Deutsche Post DHL	2
Martin Herrington	Procter & Gamble	2, 3
Carsten Hess	Deutsche Post World Net (BE)	1, 2
Ian Hodgson	European Commission, DG ENV	4
Richard Hodgson	Columbia University, N.Y. & Dalhousie University, Canada (CA)	1, 2, 3, 4
Bettina Hunold	Deutsche Bahn AG, Brussels	3, 4
Søren Hyldstrup Larsen	DTL, Danish Transport and Logistics Association (BE)	1, 2, 3, 4
Rein Jüriado	DG TREN, EC (EU)	1, 2, 3, 4
Jari Kauppila	International Transport Forum (FR)	1
Christian Kille	Fraunhofer ATL (DE)	1
Roman Kirnbauer	bmvit, Federal Ministry of Transport, Technology and Innovation (AT)	2
Peter Klaus	Fraunhofer ATL (DE)	2
Iain Knight	ERTRAC, European Road Transport Research Advisory Council (UK)	2
Helene Köpf	UNIFE, Association of the European Rail Industry	2, 3, 4
Ben Kraaijenhagen	MAN Nutzfahrzeuge (DE)	1, 2
Henk A. Kramer	TLN, Dutch Transport Operators Association (NL)	1, 2, 3, 4
Patrycja Kulesza	ECG—The Association of European Vehicle Logistics	2

Amandine Labé	Daimler AG	2
Eric Laenens	Procter & Gamble (BE)	1
Rémi Lebeda	IRU, International Road Transport Union (BE)	2
Matthew Ledbury	IRU, International Road Transport Union (BE)	1
Teresa Lenz	EuroChambres, Assoc. of European Chambers of Commerce and Industry	3
Benedikt Lippay	MAN Nutzfahrzeuge Group	3, 4
Eric Louette	Ministry of Ecology (FR)	1, 2, 3
Alexander Louvet	Powershoots	4
Isabelle Maitre	FNTR, French Road Transport Association	4
Mark Major	European Commission, DG ENV	4
Patrick Martin	Geodis	3
Fuensanta Martinez-Sans	ACEA, European Automobile Manufacturers' Association	3, 4
Thomas Meyer	Ministry of Transport (DE)	1, 2, 3, 4
Andreas Nägele	European Commission, DG TREN	
Helene Nicklasson	ERTRAC, Volvo Technology Corporation (SE)	1, 4
Peter K. Olson	Swedish Forest Industries Federation, Korsnäs AB	2
Bo Olsson	Banverket (SE)	1, 3, 4
Vicenc Pedret-Cusco	European Commission, DG TREN	4
Steve Phillips	FEHRL, Forum of European National Highway Research Laboratories (BE)	1, 2, 3, 4
Jan Pohanel	European Commission, DG TREN	3, 4
Barry E. Prentice	University of Manitoba, Canada	3
Frederik Rasmussen	European Commission, DG TREN	2, 3, 4
Nina Renshaw	Transport & Environment (BE)	1, 2, 3
Christian Reynaud	Nestear (FR)	1, 2
Michael Robson	EIM, European Rail Infrastructure Managers (BE)	1, 2, 3, 4
Martin Salet	Ministry of Transport (NL)	1, 2, 4
Wolfgang Schade	Fraunhofer ISI (DE)	1, 2, 3
Jörg Schmidt	DB Schenker Rail (DE)	1, 2
Harald Schnieder	European Petroleum Industry Association (BE)	1
Martin Schwemme	Fraunhofer—working group for logistics service technologies (DE)	3, 4
Claus Seibt	European Commission, DG RTD (EU)	1, 2
Manfred Seitz	Via Donau (AT)	1, 2
Johan Selling	Skogsindustrierna—Korsnäs	4
Jerker Sjögren	Ministry of Enterprise, Energy and Communication (SE)	4
Martin Sprynar	CESMAD Bohemia (CZ)	1, 2, 3
Sonja Starnberger	Eurocommerce (BE)	1
Wolfgang Steiger	Volkswagen (DE)	1
Jan Steinkohl	Daimler	3, 4
Dirk t Hooft	EIRAC, European Intermodal Research Advisory Council (BE)	2, 3
Erik Toft	European Commission, DG TREN	3

Simona Tomarchio	EIA, European Intermodal Association (BE)	3
Andrew Traill	European Shippers Council (BE)	1, 2, 3, 4
Mateu Turro	Universitat Politècnica Barcelona	3, 4
Nicolette Van der Jagt	European Shippers Council	2, 4
Kurt van Donink	NIKE	2
Caroline van Doorn	Port of Rotterdam	4
Kris Verhulst	Procter & Gamble	4
Marie-Laure Viala	SNCF GEODIS	4
Christina von Westerhagen	DOW Chemicals	3, 4
Thomas Wakeman	Stevens Institute of Technology (US)	1, 2, 3
Peter Wolters	EIA, European Intermodal Association (BE)	1, 4
Konstantinos Zografos	Athens University of Economics and Business	2
Branislav Zigic	Dev. Centre Ship Tech+TS (DE)	1
Thomas Zunder	NewRail-Newcastle Centre for Railway Research (UK)	1, 4

Appendix C
Agenda of the Forum Meetings

This appendix contains the agendas of the 4 FREIGHTVISION Forum Meetings.

FORUM 1 – 17 March 2009

8:30	Registration and Welcome coffee
9:00	**Opening of FREIGHTVISION FORUM 1 and project goals** *Stephan Helmreich – FREIGHTVISION Project coordinator* *John Berry – EC DGTREN*
9:20	**Essential questions from the stakeholders' perspective** Interactive round table discussions *Moderated by: Doris Wilhelmer – Austrian Research Centres*
10:00	**Key Drivers – Three different points of view: policy, technology and external** *factors* *Key Drivers: Policy – Ronald Jorna, Mobycon* *Key Drivers: Technology – Florian Kressler, AustriaTech* *Key Drivers: External factors – Stefan Rommerskirchen, ProgTrans*
10:45	Break
11:00	**Participative session on Key Drivers** Development of a joint perspective on the most important drivers and stakeholder's feedback to first project results. World café dialogue and interactive decision-making process between stakeholders and project partners. *Moderated by: Julia Düh – AustriaTech / Doris Wilhelmer – Austrian Research Centres*
13:00	Lunch
14:00	**FREIGHTVISION Model:** A Framework for Story-lines Development *Klaus Kubeczko – Austrian Research Centres*

14:30	**Participative Session on STORY-LINES** Development of narrative stories about different future trends. View on different estimations. World café dialogue *Moderated by: Julia Düh – AustriaTech / Doris Wilhelmer – Austrian Research Centres*
16:45	**Integration of the results into the next steps** *Magnus Stadler – Transver*
17:00	**Outlook to Forum 2** *Stephan Helmreich – FREIGHTVISION Project coordinator*
17:15	Farewell and end of Forum 1

Sessions highlighted with this symbol are participative sessions.

FORUM 2 – 9 June 2009

08:30	Registration
09:00	**Introduction** *John Berry – EC DGTREN* **Goals of Forum 2** *Stephan Helmreich – FREIGHTVISION Project Coordinator*
09:20	**Introduction of the new Stakeholders**
09:35	**Forecasts 2020, 2035 & 2050 – GHG, Fossil Fuel Dependency, Congestion & Accidents** *Jürgen Schmiele – TRANSVER*
09:50	**Dialogue Round – Is there Room for Shaping the Future?**
10:15	Break
10:30	**Preliminary Vision 2020, 2035 & 2050 – GHG, Fossil Fuels Dep., Cong. & Accidents** *David Bonilla – Oxford*
10:45	**World Café – Our World in 2050**
12:45	Lunch
13:45	**Conflicts: Forecasts vs. Preliminary Vision** *Olaf Meyer-Rühle – ProgTrans*
14:00	**Dialogue Round: Long-term Perspective – Measures & Opportunities**
15:15	Break
15:30	**Dialogue Round: Mid-term Perspective – Measures & Opportunities**
16:30	**Galleries**
17:15	**Closing – Summary & Outlook on next Forum** **Farewell Cocktail**

Sessions highlighted with this symbol are participative sessions.

FORUM 3 – 20 October 2009

09:00	**Opening of FREIGHTVISION FORUM 3** *Doris Wilhelmer – AIT*
09:10	**Introduction of FREIGHTVISION FORUM 3** *John Berry – EC DGTREN* **Goals of Forum 3** *Stephan Helmreich – FREIGHTVISION Project Coordinator*
09:30	**Introduction of the new Stakeholders** *Doris Wilhelmer – AIT*
09:50	**Methodology of Measure Assessment** *Martin Volny – EGIS Mobilité*
10:00	**Overview on the assessed measures Project Partner give**
10:40	**"Measure Assessment Rounds" – Assessment ROUND (1)**
11:40	Break
12:00	***"Measure Assessment Rounds" – Assessment ROUND (2)***
13:00	Lunch
14:00	**Measure Assessment & Timeline GALLERY**
14:30	**Agenda afternoon and implementation of Delegation Dialogues** *Doris Wilhelmer – AIT*
14:45	**Methodology of SCENARIO development** *Riina Antikainen – SYKE*
15:00	**Scenario Plausibility Check – 4 Delegation Dialogues**
16:00	Break
16:15	**SCENARIO Crash Test & Wild Cards**
17:00	**Plenary Session: Flashlights on Brainstorming results**
17:20	**Closing – Summary & Outlook on next Forum** **Farewell Cocktail**

Sessions highlighted with this symbol are participative sessions.

FORUM 4 – 19 January 2010

09:00	**Opening of FREIGHTVISION FORUM 4** *Doris Wilhelmer – AIT*
09:10	**Introduction of FREIGHTVISION FORUM 4** *John Berry – EC DG TREN*
	Goals of Forum 4 *Stephan Helmreich – FREIGHTVISION Project Coordinator*
09:30	**Introduction of the new stakeholders**
09:50	**Overview on the FREIGHTVISION measures' actions and milestones** *Stephan Helmreich – FREIGHTVISION Project Coordinator*
10:00	**Overview on the assessed actions by the Project Partner**
10:50	***"Measures' actions and milestones Assessment Round" – World Café Round (1)***
11:30	Break
12:00	**Introduction of the FREIGHTVISION Vision & Action Plan** *David Bonilla – Oxford, Stephan Helmreich – FREIGHTVISION Project Coordinator*
12:10	**"Action Plan Assessment Round" – World Café Round (2)**
13:00	Lunch
14:00	**Measures & Action Plan Assessment Gallery**
14:30	**Agenda afternoon** *Doris Wilhelmer – AIT*
14:35	***"FREIGHTVISION impact on individual organisations and Europe" – World Café Round (3)***
15:15	Break
15:30	**"FREIGHTVISION key aspects and benefits" – World Café Round (4)**
16:45	**FREIGHTVISION project evaluation**
17:25	**Closing – Summary & Outlook**
17:30	**Farewell Cocktail**

Sessions highlighted with this symbol are participative sessions.

Appendix D
Results of Discussions on Key Drivers

In the first Forum Meeting, key drivers for European long-distance freight transport were discussed. These discussions were done in world café dialogue rounds, where stakeholders discussed with project partners their analysis. At each table one of the following areas was discussed:

- European policy
- National policies
- Key demonstration projects and intermodality
- Infrastructure technologies and ITS
- Logistics technologies
- Engine technologies
- Socio-economic trends
- Logistics trends
- Transport demand and congestion
- Emissions

In this appendix the results of these discussions are summarized.

European Policy [1]

Comments on Key Drivers:

- GDP disparity within EU; some countries are more advanced than others. The disparity makes the achievement of an EU-wide common transport policy more difficult;
- Congestion: passenger vehicles interact with freight vehicles; but former contribute much more to congestion than freight; freight transport is smaller contributor to congestion;
- Congestion is not a real problem for freight (trucks), since most of the freight movements take place in the evening when passenger car traffic is lowest.
- Impact of current financial crisis on freight related infrastructure: ports, roads, Terminals, existing shipping capacity, freight costs.

1 Summarized by David Bonilla.

- Transport cost evolution to 2050. Costs levels will shift the location of manufacturing plants from one place to another (i.e. from China to Italy or vice versa).
- Just in time continues
- Biomass/bio fuels supply restricted as food competes with Long distance traffic continues
- Weak climate policy
- Low oil prices
- Regional development
- Consumer behaviour preferences for certain goods (i.e. Italian tomatoes to non EU tomatoes)
- EU policy and R&D innovation
- Changes in vehicle dimensions
- Carbon emissions allocation in isolation of other sectors: freight transport emissions are not negotiated alongside other sectors.
- Over regulation
- Increasing living standards – consumption for goods continues to expand.
- Hybrid trucks: these have market potential in LDFT
- Linking transport challenges with daily economic life. Not enough focus on air freight
- Intra-European trade is different from the other European trade
- National politicians are reluctant to give up power at the EU level
- Consumer choice is very important: consumers still want the fastest delivery, and the only solution to this are using lorries!

Comments on Trends:

- Other comments on your report adaptation to climate change of transport infrastructure was not mentioned at all; this could be a major factor in freight transport efficiency

National Policies[2]

Comments on Key Drivers:

- Not all EU Member States have been taken into account
- The majority of national policies are in line with the EU policy.
- Developments in non-member states – for instance Russia – influence long distance freight transport in the EU.
- Summer closure of rail freight transport in some countries. In Italy, for instance, the railway is closed in August. This results in major difficulties for companies with ongoing production/demand.

2 Summarized by Hans Zuiver.

- Ongoing debate on mega-trucks in Europe: some Member States are pro, others are against.
- The EU should 'force' Member States to change things, for instance Member States are blocking efficiency in air transport (single EU sky)

Key Demonstration Projects and Intermodality[3]

The focus of the discussions was mainly on Intermodality as this had not been a part of the first Management Summary.

Comments on Key Drivers:

- Price is the main key driver for all players.
- Flexibility and availability are very important drivers.
- Costs, service and reliability are the key drivers.
- The industry does not wish any trade off; the important drivers are service, meaning on-time arrive, transit time and costs.
- Reduction of infrastructural and other bottlenecks.

Comments on Trends:

- Different studies of eco-driving show a direct effect of 10% reduction of energy consumption and then 3–5% thereafter.
- Co-modality – while using the modes respective where they perform the best – is most important, not just shifting cargo from road to rail and inland waterway for the shift.
- Road innovation disseminates very quickly, whereas rail is very slow.
- Lack of information about other modes and possibilities is a hindrance for the development of intermodality.
- The priority for passenger transport over freight transport is a major obstacle in particular for rail freight transports.

Infrastructure Technologies and ITS[4]

Comments on Key Drivers/Additional Key Drivers:

- Reliability – customer are interested to get their freight in time
- Training and education (training and education according to the needs of industries and operators)

3 Summarized by Helena Kyster-Hansen.

4 Summarized by Frank Panse and Magnus Stadler.

- Social changes (e.g. migration).
- Emissions trade schemes
- Reliability of transport chains (more important than speed of transport)
- Differentiation of efficiency: efficiency of use (traffic performance); cost efficiency (overall economic benefit caused by the system); energy efficiency

Comments on Trends/Additional Trends

- Rail: stronger interface urban freight and passenger transport (do not forget this very important interface)
- IWW: (extension and updating) infrastructure

Wish to also Integrate in Report the Other Comments:

- "upgrade of IWW infrastructure" (e.g. harbour at black sea/Danube river)
- Separate/dedicated truck lane on motorways

Logistics Technologies[5]

Generally, it was mentioned that the scope of the report is very narrow. Intelligent Transportation Systems (ITS), technologies linking infrastructure and objects as well as technologies for the different modes and co-/inter-modality are missing. But these topics are covered in report 3.1. Further comments concerning the report can be found in the following paragraphs.

Logistics Software Technologies:

- The main key driver to implement Advanced Planning Systems (APS) is to improve efficiency and decrease total costs of serving the customers. But there exist enterprises which have to focus more on customer service because their customers request, for instance, a certain delivery speed. Therefore, the fulfilment of a certain customer service is another key driver for the implementation of APS. Furthermore, APS help to manage the long and complex supply chains which have emerged due to logistics trends such as outsourcing and offshoring. The integration of planning and execution, i.e. the link between APS and logistics hardware technologies, is by now not generally available. But individual solutions already exist. The report focuses on the large providers of logistics software technologies, but also smaller enterprises offer individualized and cheaper applications which are therefore also affordable for small

5 Summarized by Heidrun Rosic.

and medium-sized enterprises. In addition to that, open-source software is available for certain planning tasks. The importance of open-source software and cheaper applications is expected to increase in the future.

Logistics Hardware Technologies:

- For the diffusion of logistics hardware technologies, i.e. GNSS and RFID, the existence of business models is a key driver. Very well-developed business models for the application of RFID technology exist, but not for GNSS applications. Therefore, it is doubtful if the degree of diffusion of GNSS mentioned in the report will be reached. As long as there no successful business models are available, this technology will remain of minor importance. The success and the broad use of GALILEO in the business world are questionable. Information about the network/infrastructure and the vehicle is by now not very well integrated. As a very dominant trend new sensor technologies (e.g. intelligent objects) could be identified. But with respect to these technologies the cost and the energy supply remain the main barriers. Object-to-object communication will become more important in the future, allowing for a self-organization of the network without a central information database. Furthermore, the tracking and tracing of dangerous goods have to be supported by these technologies.

Other Comments

- Furthermore, the way how transportation is seen is changing; network thinking emerges as new paradigm, as opposed to pure point-to-point transportation. Therefore, the cooperation between different individual enterprises becomes crucial; this interaction is by now not very well supported by existing technologies. Logistics service providers will gain importance in the future as the degree of outsourcing will increase. Logistics service providers are able to better pool resources and needs and therefore increase the efficiency (higher utilization, fewer empty trips, etc.).

Engine Technologies[6]

As Drivers for Engine and Vehicle Technologies were Suggested:

- Relative costs of alternative technologies and fuels to conventional ones together with their availability.
- Political consensus/will to change technologies (for example, the current consensus on electrification, although it is not clear in which extent this can affect long distance

6 Summarized by Gabriela Telias.

freight transport since the current opinion is that in this sector, electrification would not be advantageous). Would this be a driver or a trend?

- Availability of oil (I think this point is related to the preparation for the moment when the oil peak is reached).
- Change of consumers' behaviour (mentioned at least by two different stakeholders). A discussion followed on whether consumers' behaviour is a driver in this sector where decisions for new acquisitions are mainly based on investment and operational costs.
- World trade trends and their influence on freight transport should be considered (relevant for technologies?).
- Urban development (mega cities) as interfaces could affect transport development (relevant to long distance sector and/or technol.)

Socio-Economic Trends[7]

Regarding Task 4.1, we have noted two points to be retained from the stakeholder meeting:

- Consumer behaviour/preferences
- impact of the crisis

Stakeholders have not clearly stated how they were expecting consumer behaviour/preferences to be included in the analysis (consumers are understood to be shippers and other businesses on the one side and households on the other side). Intermediate and final demand is part of national accounts and therefore implicitly contained in the GDP and foreign trade drivers. Furthermore they are implicitly contained in the transport demand functions and the origin-destination matrices (Task 4.3).

Five months after we defined the macro-economic trends in IR 4.2 (not even data for the third quarter of 2008 were available at that time), the situation looks indeed quite different from today (less clear now). It is questionable now if the EU economies shall eventually return to the original growth path, whether the described trend will be shifted by a few years or whether structural adjustments will change the whole framework. We suggest considering possible impacts of the crisis in the scenarios to be constructed in WP6.

Logistics Trends[8]

There was common understanding that the prevalent logistics trends (outsourcing, off-shoring and centralization) are still of relevance and due to the economic crisis cost will

7 Summarized by Olaf Meyer-Rühle.

8 Summarized by Gerhard Bauer.

stay the most important key indicator in the near future. Centralization will remain an important trend also from the perspective of supplier parks enabling just-in-time deliveries, which is very popular in the automotive industry. New logistics trends seem to be less relevant if the focus remains on total costs, whereby it has to be said that this is a very short-sighted perspective. With respect to accidents and congestion the resulting risks and uncertainties have to be taken into account as they have a huge impact on delivery time and reliability.

Transport Demand and Congestion[9]

It was argued that since approximately 80% of all congestion relates to private transport, the trends in freight congestion will be largely driven by trends in private congestion. As for private congestion, the trend is not expected to change dramatically. Although fuel costs may increase due to shortage of fossil fuels a new generation of electrified cars and hybrid cars is likely to enter the market and thus keep increasing pressure on the road network capacity. This will affect freight logistics carried in peak-hours, whereas off-peak transport will be relative unaffected.

For the freight sector, information technologies (ITS) are likely to have impact on the logistic efficiency and thus increase the relative performance in terms of better routing, higher load factor, and better co-modality.

The infrastructure was discussed. It was recognized that infrastructure is an important issue in the congestion debate. Firstly, because it may offset (old) bottlenecks as well as improve modality shifts through better terminals and re-loading facilities. The prioritized projects put forward by the EC strongly suggest that the trend will include significant infrastructure improvements although the lack of financing is an issue. It was strongly emphasized that congestion effects relate not only to road, but also to rail and ports as well. It was also discussed that congestion effects may be dampened through use of charging policies. It is expected that the trend will include European-wide congestion charging policies for trucks as for private transport, which in turn will dampening transport demand. It was also discussed that structural demographical changes may be important in a long-term perspective. On the one hand an aging population may bring down the labour force and thus reduce peak-hour driving. On the other hand, an aging but healthier population may have more transport demands compared to previous older generations. As for the trend we expect these to offset each other.

As for the trade pattern, it was expected that the trend would continue the production specialization and thus produce longer logistical chains. This in turn would emphasize the need for multimodality but also make certain transport corridors more sensitive to congestion.

9 Summarized by Jeppe Rich.

Emission[10]

Comments on Key Drivers/Additional Key Drivers:

- Consumer demand, social behaviour or social change. These are not analyzed in depth in our report, and some discussion/introduction could be given.

Comments on Trends/Additional Trends:

- I think the general trends were about the same as we indicated in the report. Globalisation/relocalisation is not very much discussed in our report, but I think it's maybe more the task of D4.1.

Many stakeholders talked about other emissions than greenhouse gases and also land use, so it was good to have them already included.

10 Summarized by Riina Antikainen.

Appendix E
Storylines

In the first Forum Meeting storylines were developed. Storylines were defined as a chain of arguments, where key drivers from different areas are combined. These hypothetical combinations (related to the project's sustainability criteria: GHG emissions, fossil fuel share, congestion, road fatalities) have an impact on freight transport.

The objective was to develop storylines for each the following futures:

- Low GHG emission future
- Low fossil fuel share future
- Low congestion future
- Low road fatalities future
- Trend GHG emission future
- Trend fossil fuel share future
- Trend congestion future
- Trend road fatalities future
- High GHG emission future
- High fossil fuel share future
- High congestion future
- High road fatalities future

Below are the storylines listed, which were developed in the Forum Meetings.

Storylines on Future Development of GHG Emissions

Trend Development:

- Stable population
- Economic growth 1.5 % average
- Not more lifted tonnes
- Global labour division has already peaked
- Goods & packaging are lighter
- Increase of local production (less intercontinental transport)
- KM increase within Europe because increased production centralisation in Europe
- Policy action fails (50% reduction until 2050)

Trend Development:

- EU policy is successful in achieving their EU goals; EU is not successful in reducing India's and China's emissions (increase due to economic development)
- EU uses regulation (engine regulation on emissions – truck, train, vessels) policies to achieve EU targets, while North America has carrot/stick (incentives + regulations) strategy to control GHG emissions.
- Global market for carbon (commodity) and internalisation of climate change costs. Will the price be high enough?

Lower than Trend:

- Fossil fuel prices increase higher than 2008 (average)
- Strong internalisation of GHG-emissions (passenger and freight)
- Energy efficiency of vehicles (engines, breaking energy. . . .) increases significantly
- Infrastructure equipment and use (⇨ more intelligent)

Lower than Trend:

- Globalisation on very low level; trade and consume only within the continents
- High emission costs for all sectors
- Fossil fuel prices are higher than 2008 (average)
- New vehicle technology electrification

Higher than Trend:

- No changes in rail, SSS and IWW infrastructure (more in road)
  ⇨ no initiatives to promote rail
- Economic growth and sectoral protectionism
  ⇨ inefficiency and no co-modality
- Technology development unsuccessful
- Contradictory environmental interests

Higher than Trend:

- Globalisation ⇧ (Africa?)
- Carbon policy: CO2 emission price too cheap to stop emitting CO2
  ⇨ Copenhagen process fails
- Public rejection to science
- Cheap and new fossil fuel resources

- No policies and funding for dissemination of new technologies due to market forces
- European rail is not meting the expectations
- EU competitiveness is not successful against cheap imports from Asia
- *Air freight is used for lower value goods*
- Disability to reach consensus in climate policy
  ⇨ No emission trading scheme
- Low oil price due to new, large oil resources
- Public looses attention to climate change mitigation
  ⇨ adaptation
- No planning and international coordination (EU level, WTO, etc.)
- Feedback effect of climate change on (food) production
- Carbon losses from forest and other high carbon stocks, e.g. biofuels

Storylines on Future Development of Fossil Fuel Share

Trend:

- Peak oil peak will be reached in the near future (until 2015)
- There will be a raising gap between demand and production
- Energy efficiency will reduce this gap
- Instability of fuel prize, a stabilisation factor will be required
- Price for energy will raise significantly, but not linear
- Not all energy sources will be accepted by the society, e.g. oil sand in Canada
- We will step out of the fuel consumption when we will have better solutions, but the lack of this solutions has to be filled in the mean time
- New refineries are more for diesel production than for gasoline
- Europe will increase decentralised energy production, e.g. biofuels
- Fossil fuels consumption will be limited world wide
- Europe will reduce the fuel consumption by energy efficiency and shifts to other energy sources, e.g. hybrids
- Efficiency of transport will increase by more efficient utilisation of vehicles and infrastructure

Lower than Trend:

- High oil price
- Though climate policy
- Allocation of fossil fuels (heating, trucks, energy, etc.)
- Availability of alternative fuels
- Increase of fuel efficiency (hybrid technology)
- Load factor of trucks ⇧ (few empty trips/trucks)
- Modal shift to rail /SSS/ IWW (but always with respect to where the energy is from)

	Effect on LDFT	Fossil fuel consumption
Modal shift	–	–
High oil price	–	+
Strong climate policy	–	+
Load factor	–	+
Technology switch, e.g. altern. fuels, hybrids, . . .	— / +	+ / —

+ . . . . working towards our goal

Lower than Trend*:*

	Effect on LDFT	Fossil fuel consumption
More railway lines (new/only freight, . . . terminals/ports	Decrease trips	+
Reduction/stop of globalization (outsourcing)	Raise product prices	+
Alternative fuels e.g. biomass, . . . (biomass requires extra freight transport e.g. fertilizers)	+ / —	+ (if locally produced)
Larger trucks	+ / — (increase demand and negative modal shift)	— / +
More efficient engines, e.g. hybrids, . . .	+ (because of lower average costs)	+
Lower speed limit for trucks (better aero-dynamics)	—	+
Labour law changes	+ (increase labour intensity of trucks)	— (due to more trips by truck and more trips within 24 hours
Automatic platooning for trucks	+	+

+ . . . . working towards our goal

Higher than Trend

- Because transport elasticity is high, with the increasing economic growth by 2050, freight transport will increase
- Road Freight will increase its market share due to consumer behaviour (Very important: The consumer wants the fastest delivery: Lorries are the only solution)
- Biofuels-use will be restricted due to issues related to biomass production

- Megatrucks will be longer: tkm will be less ⇨ fuel goes down but strong growth?
- After the crisis, strong manufacturing activity
- Oil prices low due the lack of strong environmental policy
- Information problems
- Efficiency ⇧ : low costs of products ⇨ more goods ⇨ more freight
- Overestimating the environmental challenges ⇨ people's awareness

Storylines on Future Development of Congestion

Trend:

- ITS
- Infrastructure developments for co-modality
- Passengers (external costs) will increase at similar pace
- Shipper behaviour will change (collaboration)
  ⇨ Lost of mobility increases
  ⇨ Policy need to drive that.

Trend

- Congestion rail/ports:
  - Policy driven shift from road to rail + ports
  - Passenger priority
  - Lack of financing
  - Population is resistant to land use/network development/noise
  - Inefficient information exchange
    ⇨ no capacity / no capability
    ⇨ Bottlenecks:
  - Ports to rail
  - Long haul rail to entry into networks
  - Old networks: e.g. Transit Alps
  - Road-rail interchanges are not financially viable
- 2050 certain relief (systems/technology, rolling stock)

Lower than Trend

Eighty percent of congestion is due to private. . . .

- Population slight decrease, working force strong decrease
  ⇨ congestion slight decrease

- Teleworking + teleshopping very strong increase
  ⇨ congestion slight decrease
- Marginal cost pricing (population more sensitive to external effects) strong increase
  ⇨ congestion slight decrease
- ITS improve operability
  ⇨ congestion strong decrease
- ITS improve multimodality rail and IWW
  ⇨ road congestion strong decrease
- Economic slowdown
  ⇨ car ownership strong decrease
  ⇨ congestion slight decrease
- Higher Investment + Infrastructure
  ⇨ growth
  ⇨ congestion unchanged
- Goods handling: loading factors improved
  ⇨ congestion strong decrease

Higher than Trend

- High GDP Growth
- Intensive World trade (e.g. 2nd sector moving to countries with low costs, e.g. Siberia
- Low fuel prices
- Low investment on infrastructure (just maintaining)
- No congestion charges
  ⇨ congested ports, railways and roads leading to central Europe

Higher than Trend

- Global economic growth
- No congestion charge (against the trend)
- Low fuel prices
- 90% of congestion caused by passenger cars
  - Great amount of fuel efficient cars with alternative propulsion don't pollute
    ⇨ More driving
- Not enough investments in infrastructure doesn't keep pace of growth with number of cars
- Problems for freight transport close to cities ⇨ freight hubs
- No investments in ITS

Storylines on Future Development of Road Fatalities

Lower than Trend

- Vehicle development (lane keeping, distance keeping, ITS, megatrucks)
- Infrastructure development: safety application ITS, dedicated lane, parking places (more & reservation)
- Driver education (voluntary, obligatory)
- Benchmarking
- Stricter control (data collection, . . .)
- Enforcement
- Promoting rail/public transport for passenger
- Public awareness campaign for understanding between road users

Higher than Trend

- Human factor (Training, Attention)
- ICT – road telematics applications
- Traffic intensity (increasing)
- Infrastructure
- Fleet structure
- Enforcement

85% of the accidents involving trucks are caused by passenger vehicles

- Ageing population, smaller passenger cars + megatrucks, increased road traffic + transport

Appendix F
Vision Painting

At the second Forum Meeting a "Vision" painting (Fig. F.1) was developed in co-operation with a professional drawer. First the participants were split into world café dialogue groups, where they should imagine living in a desirable future in 2050 and describe, how this future looks like:

- What was achieved? What is special about these achievements?
- What are the differences in the stakeholders' special area?
- What is surprising?

Then the ideas were collected and drawn into one picture, the vision painting.

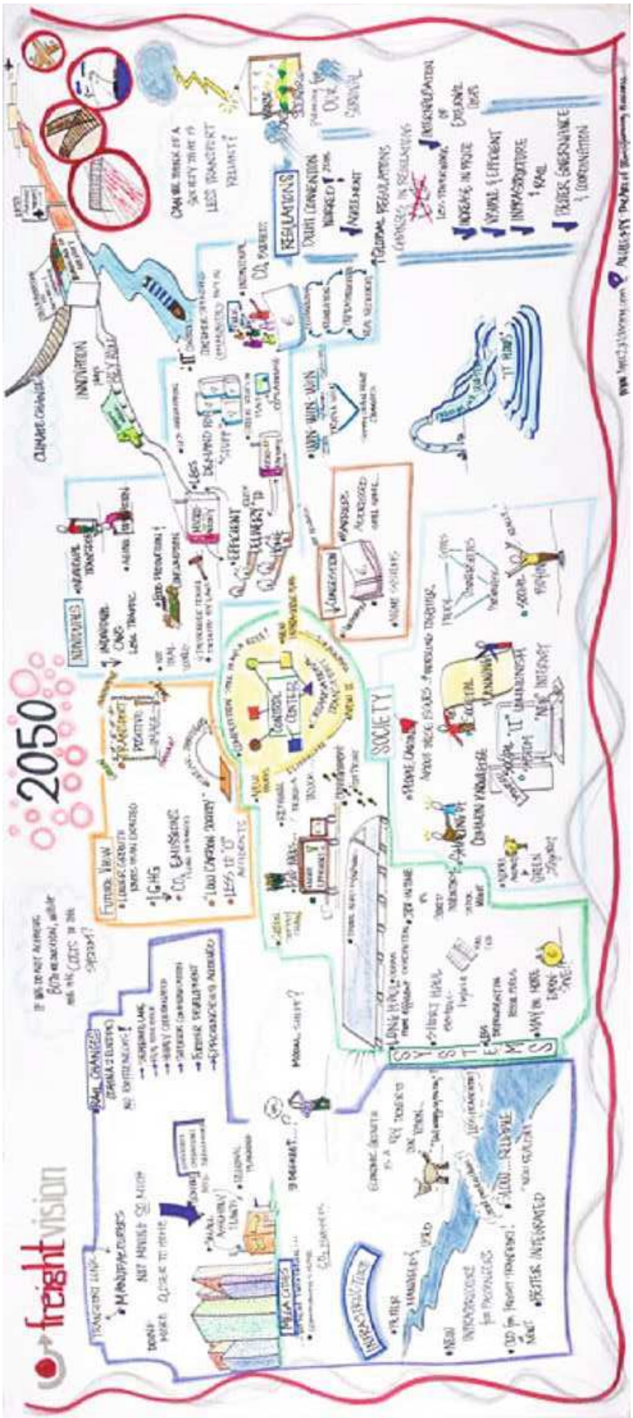

Fig. F.1 Vision painting

Appendix G
Portfolios

At the second Forum Meeting a portfolio analysis was done, to close the gap between 2050 and the present. The stakeholders, coming from different areas like infrastructure operators, logistics and transport companies, cargo owners, and vehicle and energy suppliers, thought about their opportunities to contribute to a sustainable transport system. Each world café table had one participant from each professional background and each world café discussed:

- *Which actions did we take until 2045/2025*?
- *Which actions were successful*?

As a starting point 60 actions were listed in the management summary, where the stakeholders could select from or add additional ones.

Finally the actions were benchmarked by performing a portfolio analysis. Like in the classical portfolio analysis the *x*-axis indicates an absolute number, whereas the *y*-axis indicates a growth number. In contrast to the contribution to a business criterion like profit, in this case the indicator was a sustainability criterion. By this approach the actions with

- *the highest absolute contribution and*
- *the highest growth rate*

for reaching a certain sustainability criterion were identified. For each sustainability criterion (GHG emissions, fossil fuel share, congestion, and road fatalities) a separate portfolio analysis was done (Figs. G.1–G.18). There were two rounds: one for 2025 and one for 2045.

The results of these discussions are listed below.

2025

Portfolio 1

1. Transport efficiency
    a. Short
    b. Long

2. Co_2-labels
3. DCR anti-collision m.
4. ITS – traffic management
5. Hybrid
6. Electricity
7. Fuel cell – elect.
8. Extend road cap; extend/ded. rail cap/lane; ded. truck lane
9. Larger vehicle road – gigaliner
10. Larger vehicle rail – longer trains
11. RIS – semi autom. ships
12. Interoperability ERTMS
13. E-freight
14. Electrification “green” elect.
15. Extend infrastructure waterway/- links
16. Lower fuel consumption – engines

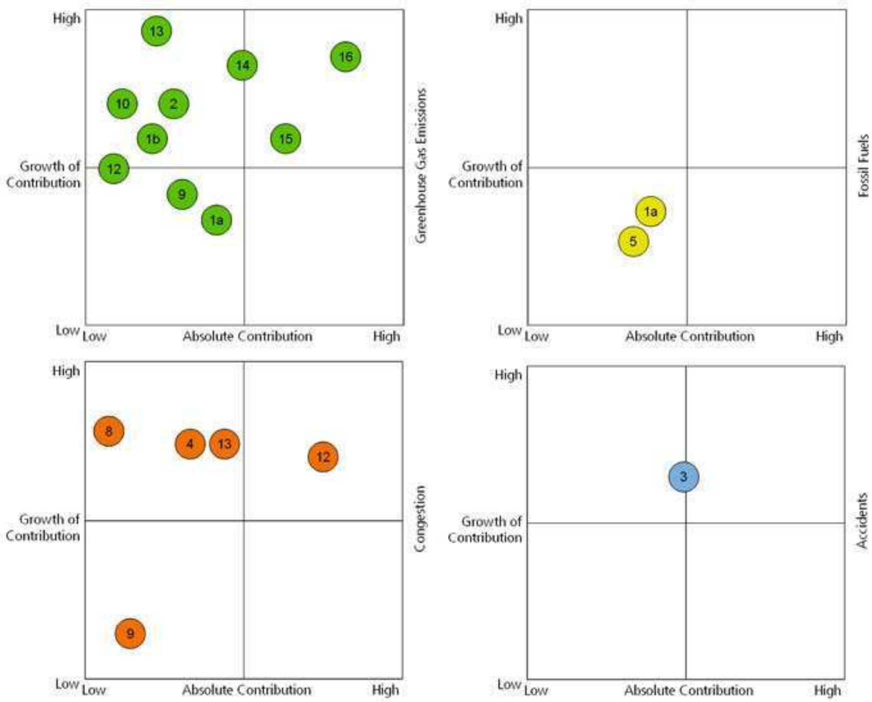

Fig. G.1 Portfolio 1

Portfolio 2

1. New road infrastructure (only eastern Europe)
2. Upgraded road infrastructure (on some important lines)
3. Biomass liquid
4. Differentiated trucks concepts (optimised truck concept)
5. Incentives/stimulation cooperation between transport
6. Gigaliners/long trains/bigger vessels
7. Stimulating cooperation between cargo owners
8. Carbon footprint imposed on operators ≥ consumer (on voluntary basis)
9. Intermodal simplification/e-freight etc.
10. Relocation of cargo destination/origin towards port/rail
11. Subsidising rail cargo
12. Renovating existing rail infrastructure ≥ electrification of railway infrastructure
13. Taxing fossil fuels (higher)

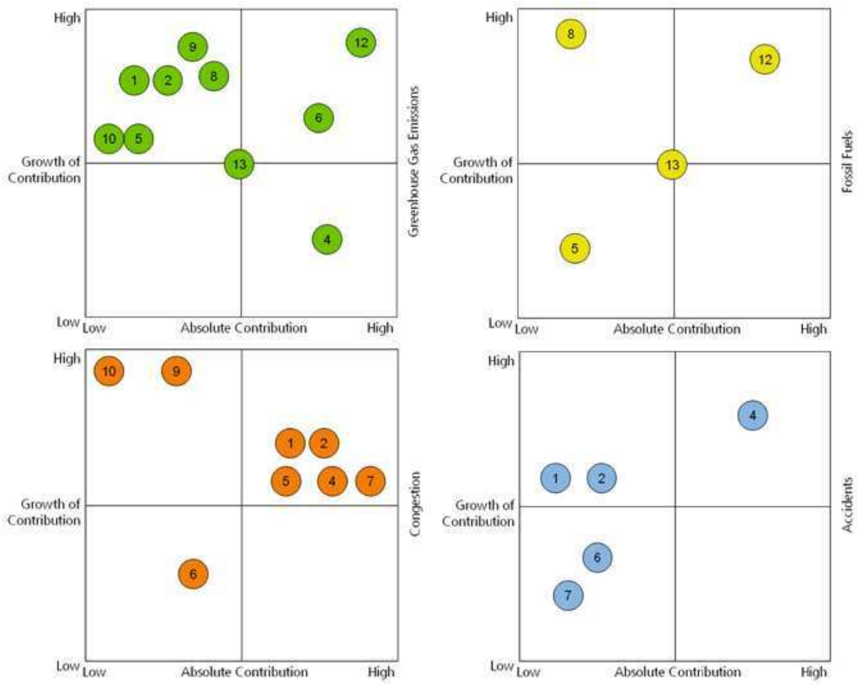

Fig. G.2 Portfolio 2

Portfolio 3

1. Missing links in the TEN-Ts (Road Infrastructure) in connection with green road freight corridors
2. Interoperability of road charging systems
3. Introduction of gigaliners
4. Free flowing cross boarder transport; full liberalisation of freight transport
5. Batteries for energy storage, electrical propulsion system; hybrid trucks
6. Multi-application platform in vehicles, incl. ITS
7. Carbon optimised supply chains
8. Access to an integrated, seamless transport and logistics network
9. Modernised and interoperable rail network
10. New rail freight liners
11. Elimination of waterways bottlenecks
12. Improve "ship speed" ≥ to transport more valuable goods
13. European standard for biofuels
14. Remove refining bottlenecks, esp. for diesel

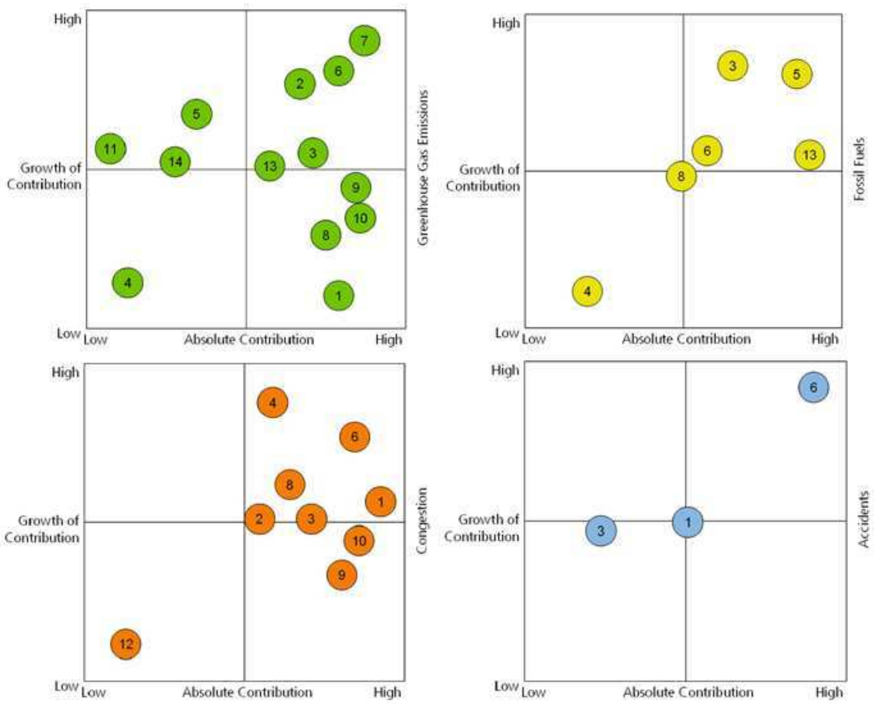

Fig. G.3 Portfolio 3

Portfolio 4

1. Investment in infrastructure
    a. Road
    b. Rail
2. Maintenance of the roadfeeders to intermodal the terminals
3. Carbon prizing introduced
4. Intermodal facilitation and simplification
5. Long distance (dedicated) rail freight lines (between terminals)
6. Hybrids are common
7. Alternative fuels (biofuels)
8. User pay principle
9. Big trucks
10. ITS applications/optimised use of existing infrastructure
11. Enforcement
12. Social standards

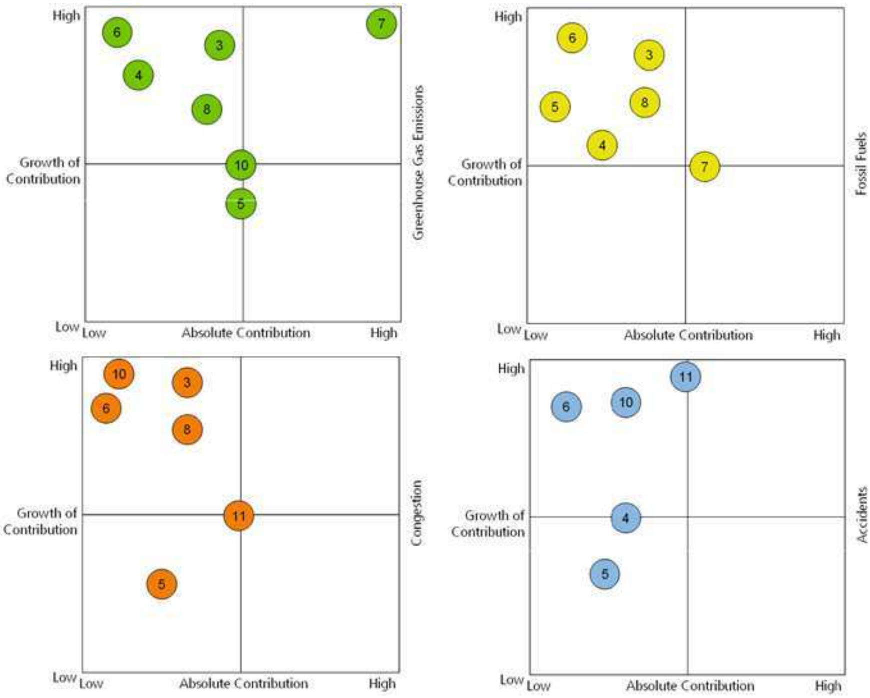

Fig. G.4 Portfolio 4

Portfolio 5

1. Close alignment with other cargo owners ($\geq$ other cargo owners)
2. Supply chain transparency ($\geq$ other suppliers)
3. "Single European Rail infrastructure" (one stop shop)
4. Global distribution system for intermodal freight transport
5. Congestion charging, but no as additional tax
6. Investment in missing links of INWA infrastructure
7. Build new fuel infrastructure (all new fuels!), build charging infrastructure for electric vehicle
8. Provide sufficient sustainable supply of biofuels
9. Continued efficiency improvements of vehicles
10. Promotion of intermodality
11. Investment in alternative energy

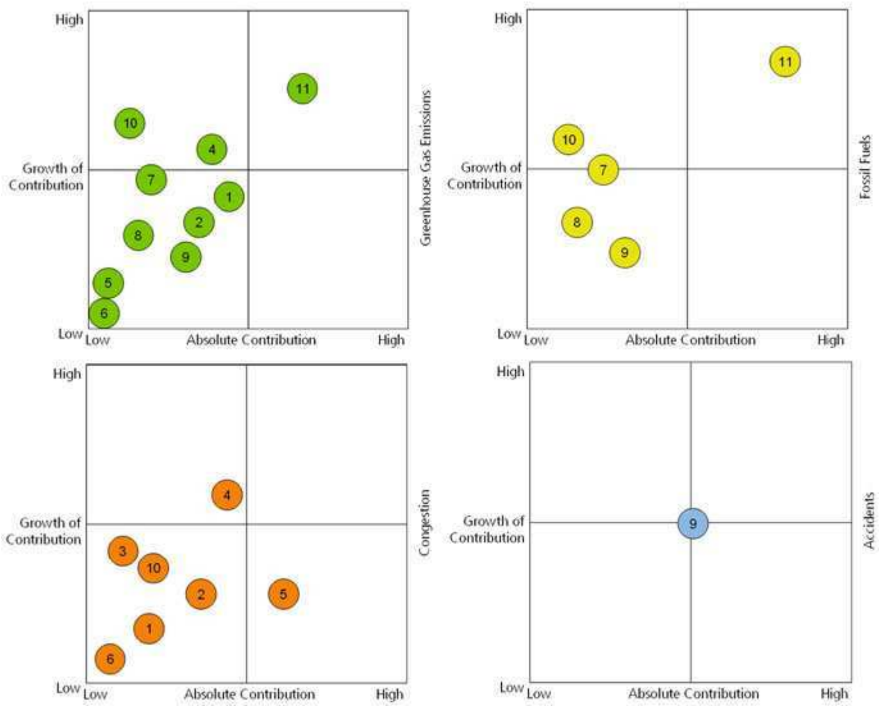

Fig. G.5 Portfolio 5

Portfolio 6

1. +8: New supply chain service -rearranging network flows
2. Greening warehouses: solar panel, refitting light bulbs
3. Applications of 100% e-commerce/ITS solution
4. Switch from air to: high-speed rail, use of road-trains
5. E-Safety/e-mobility
6. +12: Separate truck lanes
7. Multimodal contracts with carbon metrics
8. +1: Shared logistic network
9. Greening energy supply for electric network
10. Integrated network electrification
11. Traffic management and perfect timetable (for trains), without breaks
12. +6: Clearly dedicated lanes for trucks
13. CO_2-mapping for transport corridors
14. Road infrastructure
15. Emission trading schemes for energy supply
16. Measures to mitigate/adapt climate change impacts on trans infrastructure

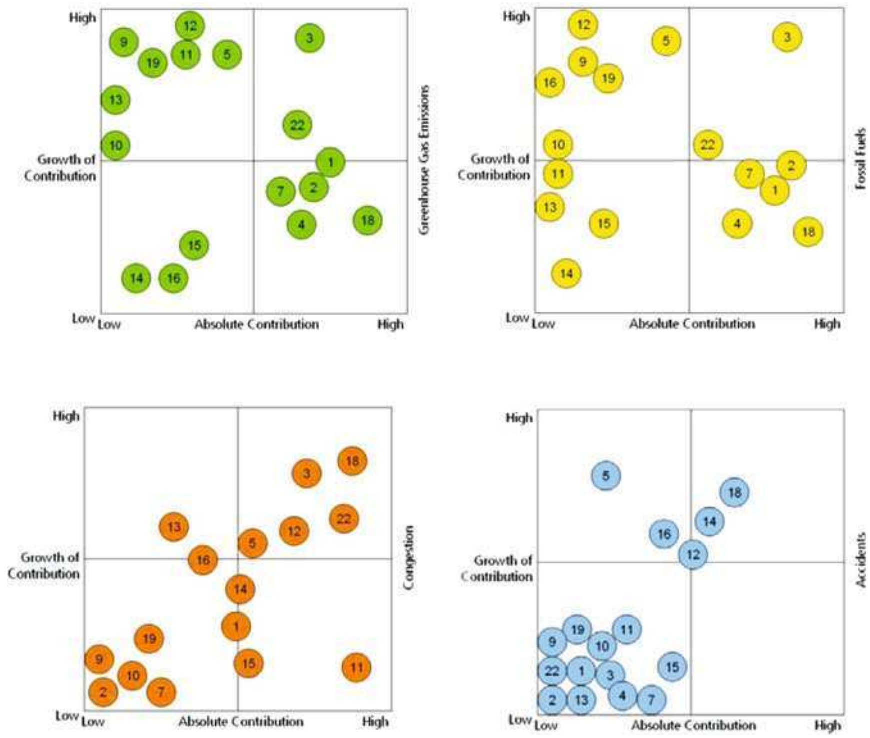

Fig. G.6 Portfolio 6

17. Economic regulation of delaying market mechanisms
18. Access to long-term finance
19. Eco-labelling the entire supply chain a seasonality metrics of CO_2
20. Urban planning to adapt to new infrastructure
21. Seamless boarder crossing
22. Harmonise train size in EU-27

Portfolio 7

1. Connection between modes
2. ITS for main corridors
3. Improve efficiency of supply chain management (less mileage)
4. Integrating transport into whole production process
5. Make eco-driving system obligatory + eco-driving training
6. Infrastructure charging
7. railway liberalisation + level playing field
8. Infrastructure investment (all modes)
9. Emission regulation for vehicles/vessels

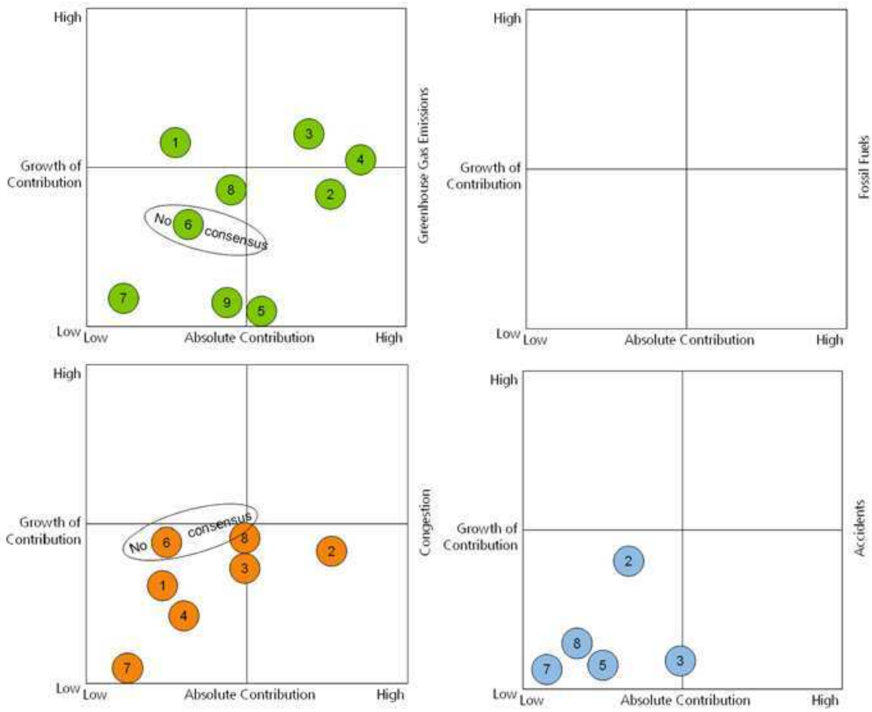

Fig. G.7 Portfolio 7

Portfolio 8

1. KPI with customers and operators find invest. & man. potential (Infrastructure rail)
2. Demand forecasts for passengers and freight (Infrastructure rail)
3. Interoperability and collaboration/cooperation (Infrastructure rail)
4. Training of staff (Logistic companies)
5. Encourage harmonisation of leg. systems (modes, countries) (Logistic companies)
6. Environmental standards (Cargo owners)
7. Steering/controlling speed ≥ traffic management (Logistics sector)
8. Investment in infrastructure bottlenecks (Logistics sector)
9. Peak – dependent road charging (Logistics sector)
10. Enlarge infrastructure for biofuels/hybrid (Energy supplier)
11. Comply with tighter regulations (Vehicle supplier)
12. Research in legal and financial aspects of ITS (Vehicle supplier)
13. Cooperate and coordinate with other modes ≥ port and traffic management (IWW)
14. Establish regular service (container) (IWW)
15. Renew fleet (IWW)
16. Network redesigns (Cargo owners)
17. Improve transport efficiency (Logistics sector)

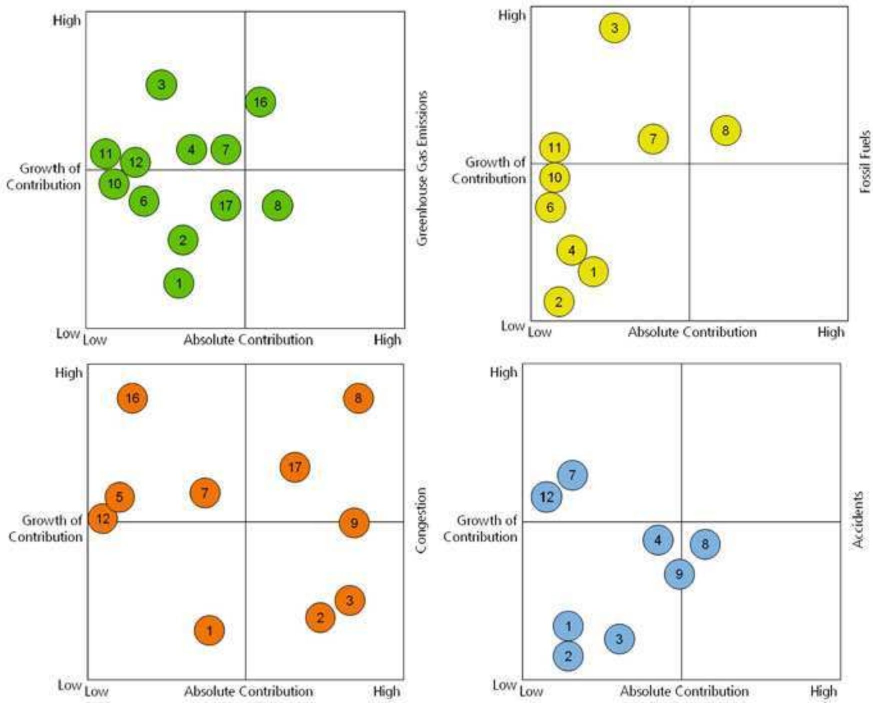

Fig. G.8 Portfolio 8

2045

Portfolio 9

1. Increase rail infrastructure investment (Infrastructure rail)
2. Rail freight corridors (Infrastructure rail)
3. Base energy production on hybrid sources ≥ renewable energy (Energy supplier)
4. Better fuel/clean fuel (Energy supplier)
5. Investment in people skills (Cargo owners)
6. Use the European modular system (Cargo owners)
7. Incentives to buy cleaner HGV (Logistics Companies)
8. Innovation ≥ better engines ≥ hydrodynamic ≥ propulsion (IIW and ports)
9. Build new roads with dedicated lanes for HGV (Infrastructure road)
10. Innovation + guidance (Infrastructure road)
11. visibility in supply chain (cooperation) (Cargo owners)
12. Traffic & transport management system Emission services (Logistics companies)

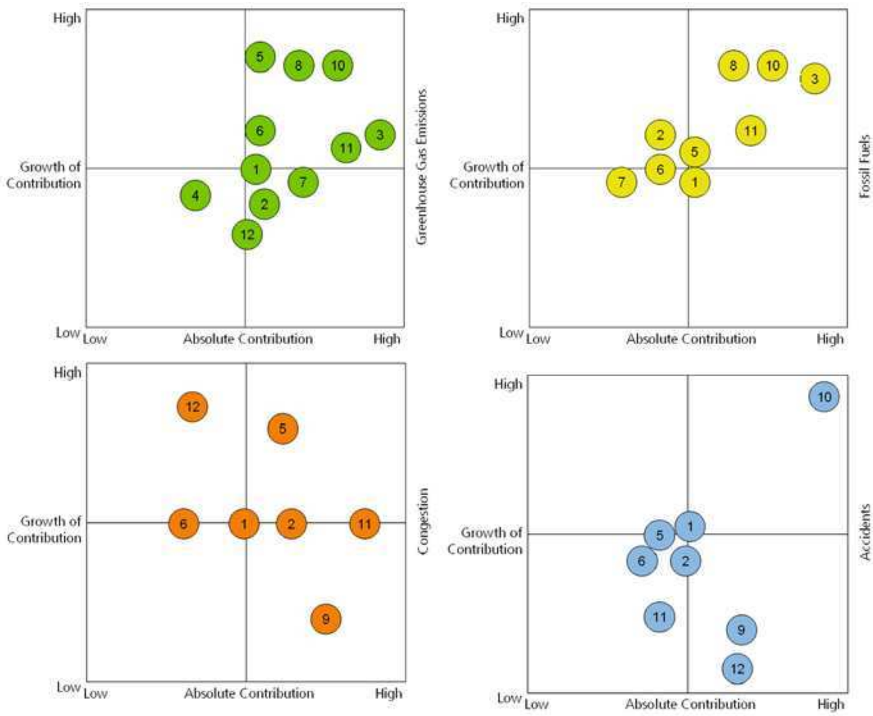

Fig. G.9 Portfolio 9

Portfolio 10

1. Emission regulation also for CO_2
2. Infrastructure charges
3. Reduction emissions from diesel locomotives (Particles CO_2 NOx. . .)
4. Eff. gains in rolling stock
5. Labelling of energy efficiency of roll stock trucks (incl. upstream)
6. Less kilometres by improves logistic
7. Reduce bottlenecks in infrastructure – rail
8. Reduce bottlenecks in infrastructure – road
9. Real-time inform for combined transport
10. Freelance truck drivers – driver towns
11. European Modular Concept
12. CO_2-labelling (life cycle) for goods
13. Alternative fuels
14. Cleaner fuels

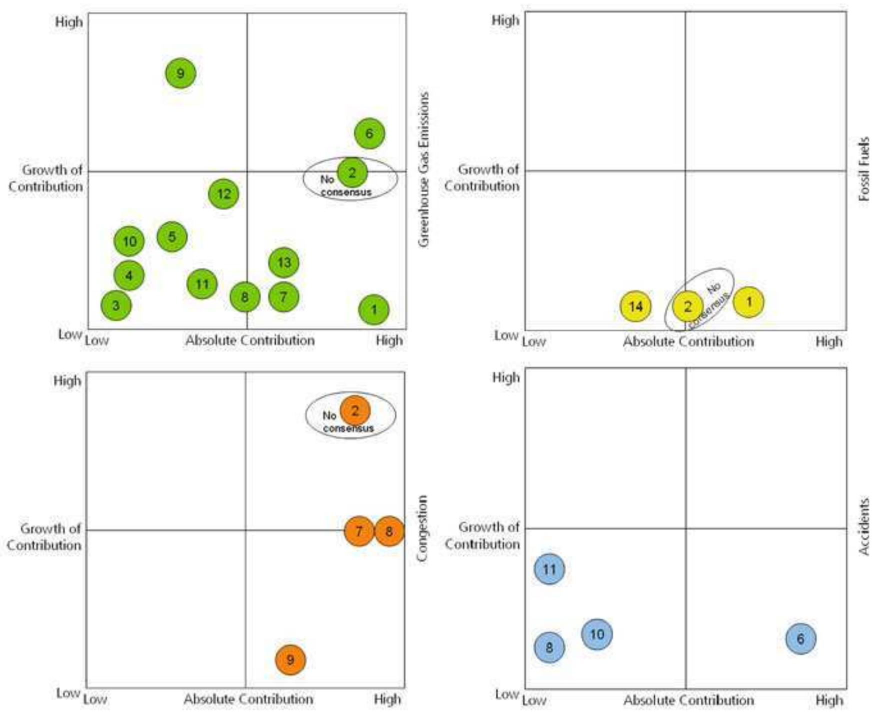

Fig. G.10 Portfolio 10

Portfolio 11

1. +8: New supply chain service – rearranging network flows
2. Greening warehouses: solar panel, refitting light bulbs
3. Applications of 100% e-commerce/ITS solution
4. Switch from air to: high-speed rail, use of road-trains
5. E-Safety/e-mobility
6. +12: Separate truck lanes
7. Multimodal contracts with carbon metrics
8. +1: Shared logistic network
9. Greening energy supply for electric network
10. Integrated network electrification
11. Traffic management and perfect timetable (for trains), without breaks
12. +6: Clearly dedicated lanes for trucks
13. CO_2-mapping for transport corridors
14. Road infrastructure
15. Emission trading schemes for energy supply
16. Measures to mitigate/adapt climate change impacts on trans infrastructure
17. Economic regulation of delaying market mechanisms
18. Access to long-term finance

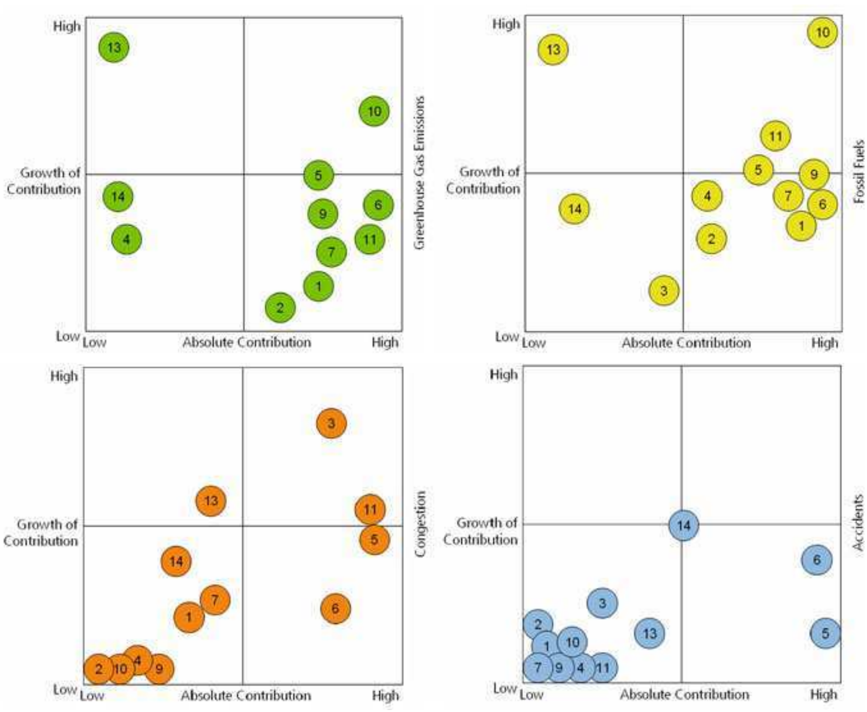

Fig. G.11 Portfolio 11

19. Eco-labelling the entire supply chain a seasonality metrics of CO_2
20. Urban planning to adapt to new infrastructure
21. Seamless boarder crossing
22. Harmonise train size in EU-27

Portfolio 12

1. Separate lanes for HGV
2. Infrastructure charging on pollution/distance/time of day
3. ITS applications C2X
4. Investment in water depth bottlenecks
   a. Build up new ships for cargo
   b. Implement river information systems
   c. Ship staff: better education
   d. Recover energy by breaking
   e. Sun connectors on cars
5. Build charging stations for electric vehicles, new fuel infrastructure (hydrog. electricity)
6. Provide sufficient sustainable supply of biofuels
7. Continued efficiency implements of vehicles

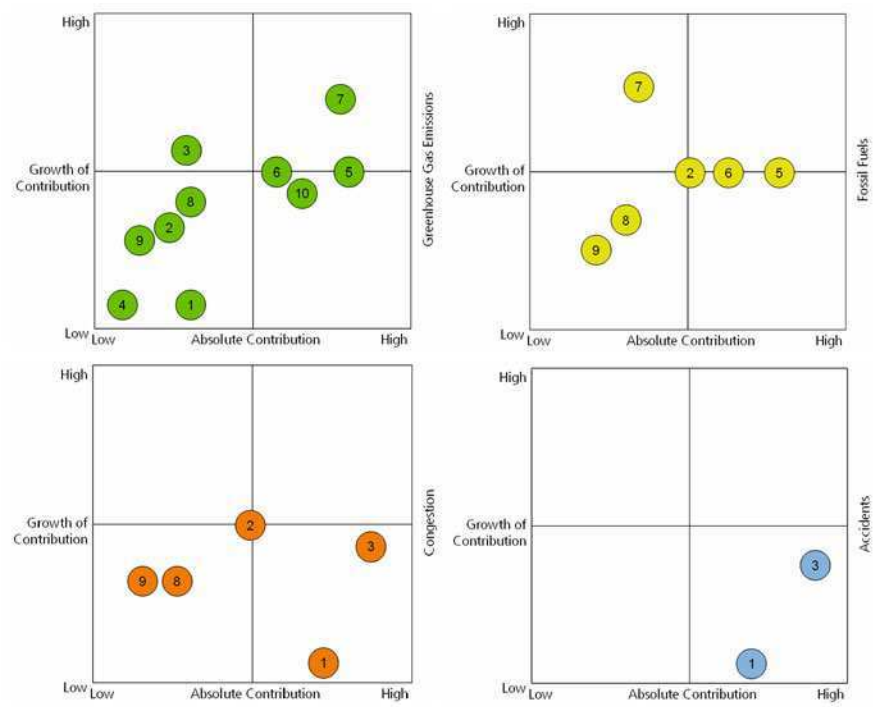

Fig. G.12 Portfolio 12

8. Provision of intermodal hubs
9. Flexible, dedicated rail-lanes for freight trains
    a. Brand new automated intermodal system
    b. Close alignment with other cargo owners
    c. Supply chain transparency
    d. Managing costumer expectations
    e. Establish requirements towards transport partners
    f. Promote intermodal transport co-modality
10. Logistics/ITS systems

Portfolio 13

1. Pricing on carbon (carbon into commodity hybrid/level of disaggregation part
    ≥ between energy suppliers
    ≥ user/consumer)
2. Hybrids
3. Alternative fuels (biofuels)
4. Integration of infrastructure (road), truck, driver, logistics
5. No cabotage (road)

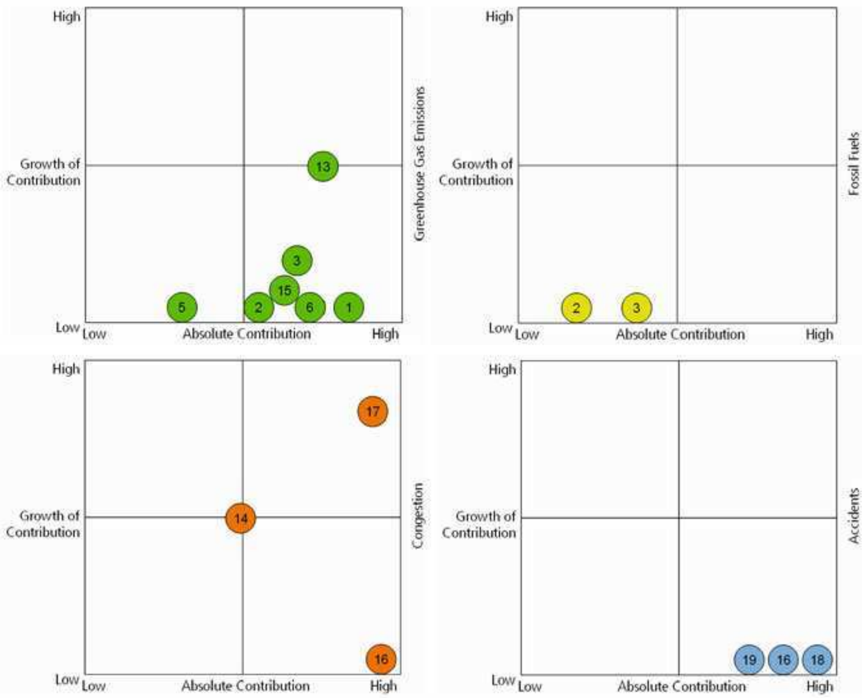

Fig. G.13 Portfolio 13

6. Applying user pay principle
7. Payment system like roaming system
8. Polluter pay principle
9. Unitized cargo increased intermodalization
10. Automation of cargo handling
11. Harmonization of borders
12. Charging dwell time
13. Optimizing of supply chain
14. Long-distance rail infrastructure
15. Gigaliners
16. Segregation of freight and passenger transport
17. Congestion pricing
18. Enforcement of legislation (road)
19. ITS

Portfolio 14

1. Modernisation of rail infrastructure
2. Special rail freight pines/corridors
3. Bottlenecks in waterways eliminated

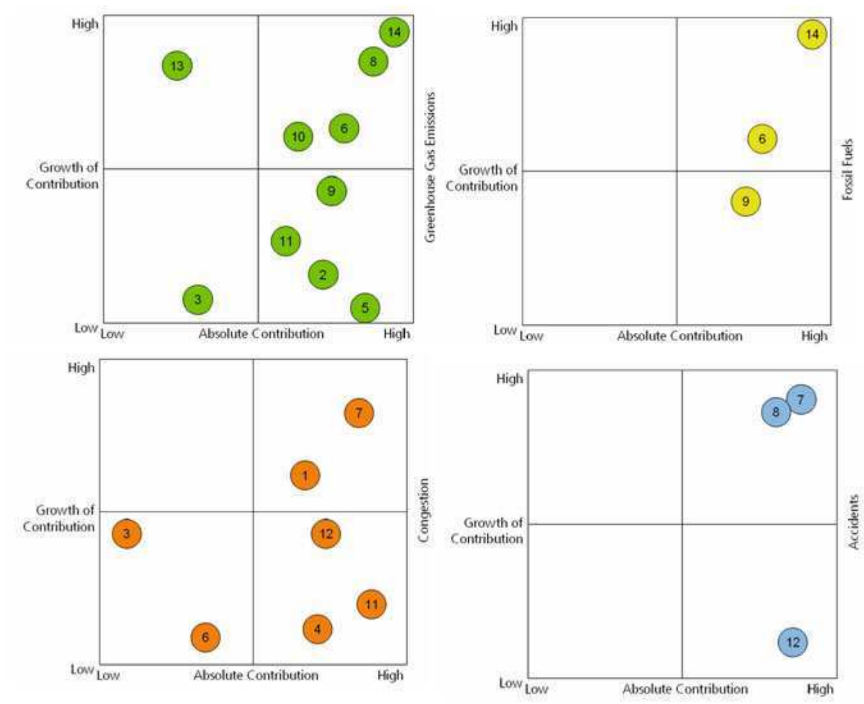

Fig. G.14 Portfolio 14

4. new transhipment technologies, faster transhipment, enhance capacities
5. Labelling of products/tracking and tracing
6. Liability across modes
7. Implementation of ITS in all modes
8. Galileo
9. Use of alternative fuels/engines
10. New mobility concepts connecting different modes
11. Filling missing links
12. Investments in maintenance
13. CCS carbon capture & storage
14. Energy mix ≥ renewables

Portfolio 15

1. New road infrastructure
2. Upgraded road infrastructure
3. Biomass liquid
4. Differentiated trucks concepts (optimised truck concept)

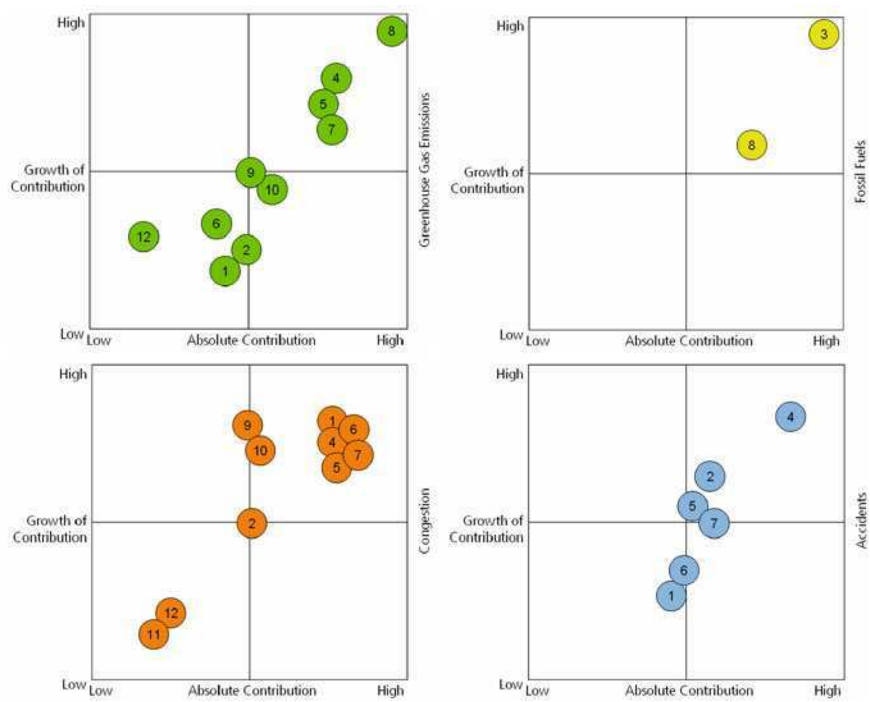

Fig. G.15 Portfolio 15

5. Incentives/stimulation cooperation between transport (all modes)
6. Gigaliners/long trains/bigger vessels
7. Stimulating cooperation between cargo owners
8. Carbon footprint imposed on operators ≥ consumer
9. Intermodal simplification/e-freight etc.
10. Relocation of cargo destination/origin towards port/rail
11. Subsidising rail cargo
12. Renovating existing rail infrastructure ≥ electrification of railway infra
13. Taxing fossil fuels (higher)

Portfolio 16

1. Gigaliners
2. Speed harmonisation (passenger + freight) ≥ about 95 km/h
3. Increased taxation of fossil fuels
4. Improved batteries
5. –
6. Renewable fuels (biofuels long distance)
7. Rail network liberalisation all over Europe

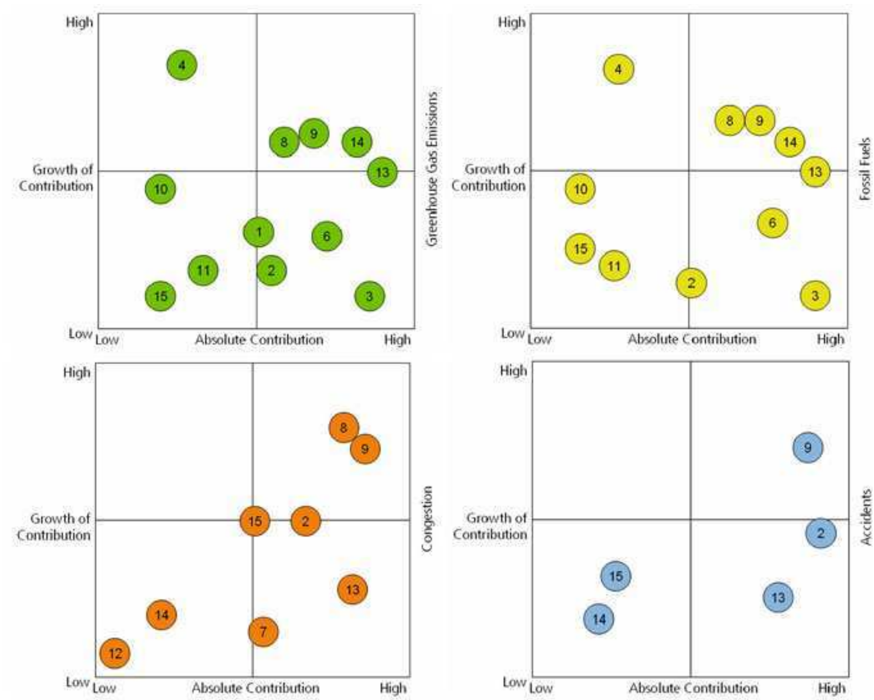

Fig. G.16 Portfolio 16

8. Special tracks for freight in rail ≥ leads to more capacity and therefore has an impact on other modes
9. ERMTS – management systems control of trains
10. Ports: investment on infrastructure ≥ green ports (less emission and more energy efficient)
11. Biofuels for ships in inland waterways
12. More rapid locks in inland waterways (fast movement of ships)
13. Improved stock management, from just in time to right in time delivery
14. Carbon footprints/carbon budget permits
15. Consolidation of transport

Portfolio 17

1. Transport efficiency
   a. Short
   b. Long
2. Co_2-labels
3. DCR anti-collision m.

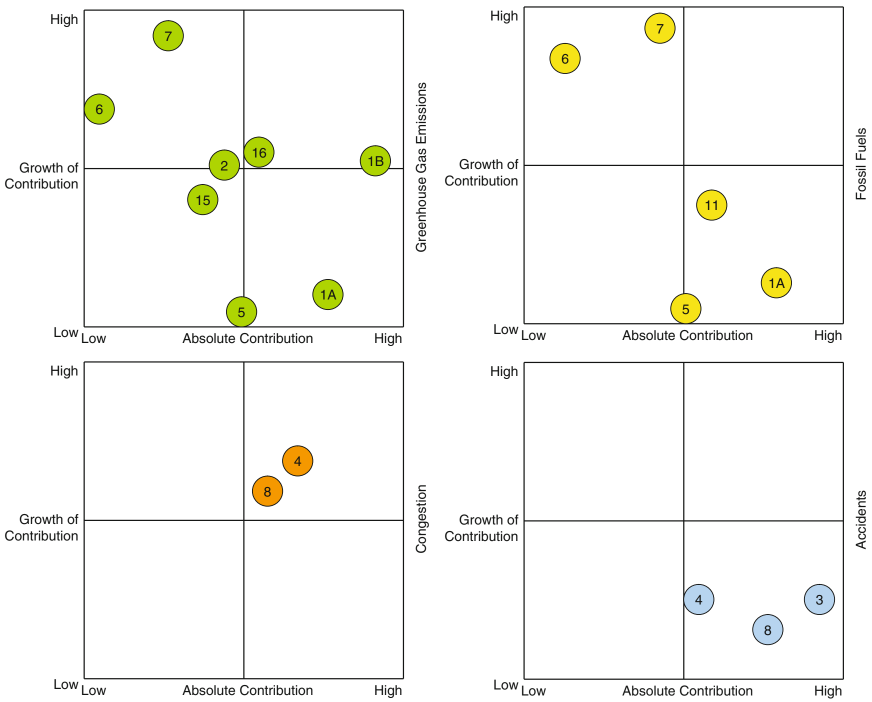

Fig. G.17 Portfolio 17

4. ITS – traffic management
5. Hybrid
6. Electricity
7. Fuel Cell – elect.
8. Extend road cap; extend/dedicated rail cap/lane; ded. truck lane
9. Larger vehicle road – gigaliner
10. Larger vehicle rail – longer trains
11. RIS – semi autom. ships
12. Interoperability ERTMS
13. E-freight
14. Electrification "green" elect.
15. Ext. infrastr. waterway/links
16. Lower fuel consumption – engines

Portfolio 18

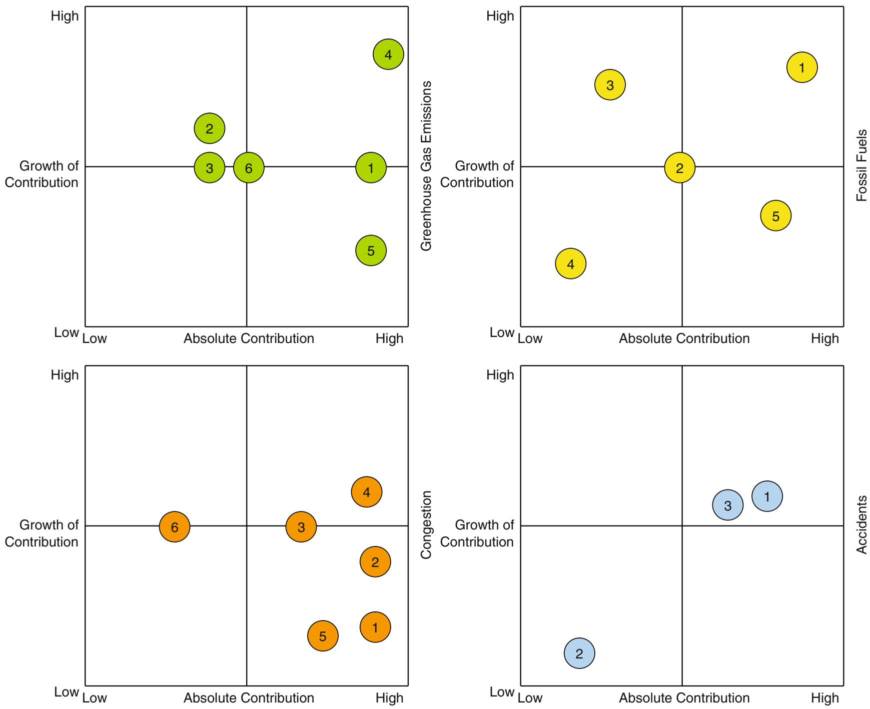

Fig. G.18 Portfolio 18

GHG 1. Interconnection – road, rail, water 2. Cross-docking urban deliveries freight 3. Cross-docking passengers 4. Light duty freight 5. Smart taxation of fossil fuels 6. Inl. waterway low sulfur fuel	Fossil Fuel Share 1. Hybrid truck fully available, long distance 2. Biofuels 2nd/3rd generation 3. 20% nuclear, 10% coal, 70% renewables 4. High-speed freight at night 5. Dedicated freight lines maintenance
Congestion 1. Infrastructure road 2. JTS/European networks 3. Missing links 4. Road train possible 5. Fully single market for all transport modes interoperability 6. Organisation of Inl. barge industry ≥ logistic industry ≥ floating warehouses ≥ pallet deliveries urban areas	Accidents 1. Truck lane 2. ERTMS 3. Fully guided truck systems

Appendix H
Wild Cards/Paradox/Positive

At the third Forum Meeting the robustness of the scenario was checked by a wild card-brainstorming sessions. Three different perspectives were taken:

- Wild cards: Which low-likelihood, high-impact, hard-to predict events influence the scenario?
- Paradox: What can I do to assure that the scenario will fail?
- Positive: What can I do to assure that the scenario will come true?

The results of these sessions are listed below.

Wild Cards

- Availability of alternative energy
- Climate change (sea level rise, permafrost melting, desertification)
- More environmental criteria
- Equalized labour costs globally (China, India)
- Climate change starvation, migration
- War for resources
- Pandemic
- Coordination of actions on GHG within EU
- Energy prices + raw materials
- Recession 2 more years
- Protectionism
- Nuclear batteries
- Radical reduction of carbon costs
- Biofuel production leads to social unrest ≥ limited impact, medium likelihood
- Nuclear disaster ≥ high impact, medium likelihood
- High oil price ≥ high likelihood
- Heavy weather conditions ≥ likelihood
- Terrorism, restriction of global trade, falling states in the direct neighbourhood ≥ high likelihood
- Earth quake on major Axes
- More homework
- Cheap available oil ≥ massive decrease
- Economic crisis and negative growth/growth decline

- Automatic full platooning (automatisation)
- Mass migration
- Automated guided vehicle
- Growth faster out recession
- Manufacturing costs are balanced/relocalisation
- Break through in nuclear fusion or 50% solar power share
- Virtualisation of production/home production – fabber, etc.
- Ban or restriction of rare earth metals/resources
- Double stacks
- Gigaliners
- Energy war (peak oil, gas, coal) ≥ shortage of resources leads to decreasing mobility substitution (biofuels, electricity tar sands, coal to liquid)
- Failure of climate change, mitigation negotiations ≥ questioning the vision, worse than BAU
- Extreme weather conditions cause truck traffic to come to stop ≥ more electric
- Solar storm cause Galileo + power supply etc. to fail ≥ less electric
- Energy war
- War for water
- Economic crisis
- Migration due to climate change
- Nuclear fusion
- Breakthrough in biofuels e.g. algae
- “Virtual manufacturing”
- Local production
- Breakup of the EU
- Civil war
- Nuclear accident in Europe
- (Environmental) terrorism
- Rising sea levels – frequent flooding
- Food crisis
- Peak oil
- Failure of climate mitigation negotiations

Paradox

- Promote diesel – brings most flexibility
- Increase costs of rail
- Increase share of road transport
- Use of diesel locomotives
- Close of regulatory bodies
- Protect market – no cabotage
- Reduce truck size
- Skip all programmes (Ecodriving etc.)/no research
- More scheduled services with regards to road/rail

- Half fuel price
- Produce electricity by coal
- Longer life-time of vehicles
- Publicity campaign for trucks
- Close feeder lines/just block-trains on main routes
- Unity working hours (start/end)
- Unity holiday's/school hours
- Unity delivery windows/make them smaller
- Night time ban
- Intensity global trade/off shoring
- Restrict truck size
- Increase costs of rail
- No investments in infrastructure

Positive

- Further research on actions
- Raise (education) awareness ≥ innovations
- Consensus of action vs. market driven actions
- Integrated transport information (all modes)
- Integrated info-system to react on shocks
- Introduce new key indicators (students)
- Integration of hard- and software ≥ improve transport planning & control
- Legislation – combined transport
- Update clients with new EU-legislation
- Representing industry ≥ not hindering good developments (green paper)
- Behavioural change: Institutional commitment to CO_2 limits
- Buy local
- Global agreement on CO_2 emissions of transport (UN, EV, WBank)
- Adopt Swiss Programme on infrastructure charging
- Persuade WBank to subsidise green projects
- Adopt vigorous fuel economy standards

Appendix I
Pre-Forum Meetings

In the late afternoon the day before the FREIGHTVISION Forum Meetings, a "Pre-Forum Meetings" took place. These Pre-Forum Meetings started with a presentation by an external speaker, who was neither member of the project team nor a Forum participant. These talks introduced into the topic of the Forum Meeting. The topics and the speakers of the Pre-Forum Meetings are listed below.

1st Pre-Forum – "Foresight"

Driving and Delivering Foresight: Why, How and What for?

Ian Miles, Manchester University

This talk explained why Foresight exercises are continuously becoming more important, even as the future seems to be becoming less predictable, why "Foresight" has emerged as an alternative to traditional forecasting and future studies, and why governments around the world so often have invested in major Foresight exercises. The main approaches and principles of Foresight work are examined, together with the ways in which Foresight can be of benefit to its participants, and other users.

Ian Miles is Professor of Technological Innovation and Social Change at the Manchester Institute of Innovation Research, Manchester Business School, University of Manchester. His work, in addition to Foresight studies, centres on service innovation, knowledge intensive business services, and related policy issues. He was trained as a social psychologist, and has earlier worked at the Science Policy Research Unit.

2nd Pre-Forum – "Costs of Climate Mitigation"

Mitigating GHG Emissions – Costs and Options for Transport versus Other Sectors

Jens Borken-Kleefeld, IIASA

Reducing emissions of climate gases is high in the agenda. However, costs and reduction potentials vary significantly across economic sectors and countries. This talk will analyse the technological options for the transport sector and place potentials, investment costs and savings into the context with other sectors.

Dr. Jens Borken-Kleefeld is researcher at the IIASA (International Institute for Applied Systems Analysis) in Laxenburg/Austria responsible for the transportation sector. He has been working on environmental impact assessment of transportation for more than ten years. IIASA has developed a scientific tool to support analysis and climate negotiations. The so-called GAINS model allows identifying the most cost-effective way to reduce GHG emissions, across sectors and countries.

The Economic Crisis and Expected Impacts on Mobility and Freight Transport

Werner Rothengatter, Karlsruhe Institute of Technology

The economic crisis started in late 2007 on the US mortgage market and has affected the world economy dramatically. World trade is expected to go down by 10% in 2009 and many countries suffer from shrinking GDP and rising unemployment. The export champions, who have profited most from the expansion of globalization, have been hit the hardest. Governments try to avoid the failures from 1929 and spend huge sums for stimulus packages. Together with decreasing tax income this leads to the consequence that 13 out of 16 countries of the European Monetary System will not fulfil the Maastricht criteria in 2009 and the forthcoming years. Transport is a derived activity and dependent on disposable income (passengers) and trade volumes (freight). Accordingly, a massive slowdown of international freight transport is reported. But a deep crisis also has a positive side effect, which is a change of economic routines and structures to prepare the economy for the next growth cycle. In the presentation the possible consequences for economic sectors as well as for freight transport and logistics are discussed.

Professor Werner Rothengatter was head of the Institute of Economic Policy Research of the Universität Karlsruhe (TH). He is one of the Academic Directors of the International Department of the University. He is a member of the scientific advisory boards of the German Ministry of Transport, of the Deutsche Bahn AG and of the German Society of Logistics. He was the President of the World Conference on Transport Research Society from 2001 to 2007 and is a member of the Steering Committee. He has published about 80 articles in refereed journals and is author or editor of 14 monographies as for instance “Megaprojects and Risk” or “Procurement and Financing of European Motorways”.

3rd Pre-Forum – “North America”

“North American Freight Infrastructure and Environmental Policy”

Barry E. Prentice

Transportation policy in North America is fragmented and uncoordinated. The lack of connectivity between Canada, the United States and Mexico is a result of institutional poverty. Although the three countries signed a North America Free Trade Agreement

(NAFTA) in 1994, they established no institutions to deal with transportation policy. Of course the continental policy vacuum on transportation is not unique; NAFTA is a customs agreement that cannot even deal with creeping protectionism caused by the economic exigencies of a deep recession. A recent agreement on carbon policy has been announced by the leaders of the three member countries, but no consensus exists on the cause of climate change or the means of reducing the Greenhouse Gas (GHG) emissions of transportation.

National priorities within the NAFTA countries overwhelm continental concerns and the need for coordinated action. Apathy exists toward the European experience in dealing with transportation and the environment, and even the thought of learning from others. Some interesting efforts are being made to reduce GHG emissions at local levels, but all this is being done sub-nationally within the NAFTA members. Clearly the directives of the European Union are not always followed, or followed consistently, but policies at the trading bloc level are discussed. In North America there is no sense that anyone wants to make a "bigger cake". The size of the slice still dominates thinking and transportation policy as a result.

This presentation traces the development of transportation policies in North America and the opportunities to encourage a more environmentally sustainable trading relationship. The separateness of the NAFTA member country's transportation policies are highlighted, together with the harmonization that has occurred over time. The gaps in policy are highlighted and the easy wins for the environment are identified.

Barry E. Prentice is a Professor of Supply Chain Management, at the I.H. Asper School of Business, University of Manitoba and the former Director (1996–2005) of the Transport Institute. His major research and teaching interests include logistics, transportation economics, urban transport and trade policy. Barry Prentice holds a degree in economics from University of Western Ontario (1973) and graduate degrees in agricultural economics from University of Guelph (1979) and University of Manitoba (1986).

Barry Prentice has authored or co-authored more than 250 research reports, journal articles and contributions to books. His scholarly work has been recognized for excellence in national paper competitions and awards. In 1999, National Transportation Week named him Manitoba Transportation Person of the Year. Through the Transport Institute, Barry Prentice has organized national and international conferences on sustainable transportation (Railways and the Environment), supply chain logistics (Planes, Trains & Ships), agribusiness logistics (Fields on Wheels), the potential use of airships for northern transportation (Airships to the Arctic) and food trade between Canada and Mexico (La Cadena de Frio). In 1999 and 2003, he received University of Manitoba Outreach Awards.

He was instrumental in founding a major in transportation and logistics within the B.Comm. (Hons.) program at the I. H. Asper School of Business (autumn 2003). Since that time a new Department of Supply Chain Management has been formed, and in 2006 a M.Sc. program in supply chain management was initiated.

Barry Prentice has served on the Boards of Directors of several transportation organizations: National Transportation Week (President, 2001 and 2003), Honorary President of the Canadian Institute for Traffic and Transportation (2001–2003) and the Canadian Transportation Research Forum (Past President, 1997). Dr. Prentice is

the President of ISO Polar Airships that he co-founded in 2005 as a not-for-profit research institute to promote the use of airships as sustainable transport for the northern latitudes. He is Associate Editor of the Journal of Transportation Research Forum. In addition, Dr. Prentice has served on Winnipeg Airports Authority, Inc. (1998–2003), Winnipeg TransPlan 2010, the Mid-Continent International Trade Corridor Task Force, the Rapid Transit Task Force, expert committees, and is frequently asked to speak on the topics of trade and transportation.

"United States' Future Freight Transport Challenges and Technology Solutions"

Jeannie Beckett, The Beckett Group

Efficient movement of freight within the United States and across its borders is a critical enabler of future U.S. economic growth and competitiveness. Such efficiency is now threatened by capacity bottlenecks, inefficient use of some components of the freight infrastructure, interference with passenger transport, the system's vulnerability to disruption, and the need to address important emission and energy constraints. Jeannie Beckett will discuss the challenges the United States is facing in freight transportation over the next 20 years and focus on technology solutions that will leverage current capacity to meet the future needs.

Jeannie Beckett is the Principal of The Beckett Group, a certified women's business enterprise that specializes in assisting clients in finding simple solutions to complex transportation challenges. Jeannie Beckett brings more than 25 years experience from public sector port management experience to the challenges faced by public and private stakeholders with expertise in freight and goods movement planning. She is skilled in projects that involve intermodal freight systems planning, freight transportation economics, and maximizing the efficiency of multimodal goods movement systems. She has extensive project design, project management, public involvement, and data analysis experience which she earned both in the public and private sectors. Jeannie Beckett has worked on multiple projects that profiled the logistics and freight delivery needs of industries in the Puget Sound Region of Washington State. These projects pinpointed areas of inefficiency in the highway and rail freight delivery systems. Jeannie Beckett provided data to the State and other stakeholders to support the creation of a strategic infrastructure and operations investment plan for the region's freight transportation network. In this work, she was able to provide a priority listing of which projects would provide the best ROI as related to freight mobility for the region. In addition, Jeannie Beckett has worked with variety of state-wide and regional freight planning agencies to maximize the efficiency of their freight transportation systems.

4th Pre-Forum – "Copenhagen Process"

The talks gave inside into the Copenhagen process:

- What has been discussed regarding transport; what has been proposed/discussed/rejected by whom and why?

- What are the implications for transport (especially on European and intercontinental level)?
- What are the next steps (actions and goals) on European and MS level to expected/needed?

Klaus Radunsky, Umwelbundesamt (AT)

Klaus Radunsky is the Head of Unit of the Emission Trading Registry Department of the Umweltbundesamt GmbH (Federal Environment Agency) in Austria. He received his Dr. (Phil.) in Chemistry at the University of Vienna in 1979 – principal subjects were Analytical Chemistry, Physics and Mathematics.

In 1975 he started work as Chemical-technical expert at the Federal Ministry for Health and Environmental Protection, Bacteriological-Serological Institute and started to establish Air Quality Monitoring in Austria.

As of 1985 he is now working at the Umweltbundesamt GmbH first as Expert in the Department for Air Quality and as of 1995 as Head of Unit. His main activities and responsibilities include:

Representative of Austria in international fora related to climate change issues with main focus on adaptation (UNFCCC: COP, COP/MOP, SBSTA, SBI, AIXG, CEN, ISO, CEPS, IPCC, and Expert Groups under the NWP).

Co-ordination of National Monitoring of Air Pollutant Emissions and Air Quality in Austria, EU bodies (Committee under the Monitoring Mechanisms, Expert Group on Adaptation) and National Bodies (IMK, FNA 139, WG5 of FNA 226)

Projects abroad (for example):

- Slovakia: 2000–2001: Twinning Project Strengthening of Institutions in the Sector of Air Pollution
- Bosnia and Herzegovina: 2000–2001: Preparation of Environmental Legislation for Bosnia and Herzegovina
- Slovakia, Hungary: 1990–1993: Measurements and analysis of transboundary air pollution (region of Bratislava, Hungarian border region)
- Slovenia 1993–1997: Austrian Assistance Programme for retrofitting the Caloric Power Plant Sostanj in Slovenia
- Hungary: 1993–1996: Co-operation in National Ambient Air Quality Monitoring with the Hungarian Academy of Sciences

Mark Major, DG ENV

Mark Major is scientific officer in DG ENV.

Appendix J
Model for Calculating Long-Distance Freight Emissions and Energy Consumption – Forecast Parameter 2005–2050

Tuomas Mattila and Riina Antikainen

The SYKE-model is described in Chap. 3. In this Appendix the development of the parameters used in the forecast are described. The three forecasts (low, trend and high) are described in Chap. 6.

Emissions per MJ of Fuel Energy

Direct emissions are caused when the fuel is used. These emissions are often called tank-to-wheel (TTW) emissions and are zero for electricity and hydrogen. Combustion of biofuels causes direct emissions, but they are commonly ignored in calculations, since the carbon emitted in combustion is subsequently reabsorbed to biomass if the biofuel is sustainably produced.

Greenhouse gases are emitted also in the production and distribution of fuels. These emissions are called upstream emissions (often referred to as well-to-tank (WTT)). They vary significantly by fuel, by raw-material and refining technology options.

The following fuel types were considered as relevant for the time period 2005–2050:

- diesel
- oil-shale based diesel
- coal-to-liquid diesel (CTL)
- gas-to-liquid diesel (GTL)
- natural gas (CNG)
- biofuels: biogas (CBG), biodiesel (FAME, for example RME) and synthetic biodiesel (biomass-to-liquid diesel, BTL)
- electricity
- hydrogen

Ethanol and gasoline were excluded since they were not used in heavy trucks in 2005, and it was estimated to be unlikely that trucks would shift to gasoline engines, which have a lower efficiency than diesel engines.

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Table J.1 Direct and upstream emissions of energy sources considered

Energy source		Density kg/m^3	LHV MJ/kg	Carbon %m	g CO_2 eq/MJ	
					Direct	Upstream
Conventional diesel		832–835[a]	43.1–43.0[a]	86.1–86.2[a]	73.25–73.54[a]	12[b]–14[c,d]
Oil-sand diesel		Same as conventional diesel				12.9–40.7[c,e]
Biodiesel	FAME/RME	890[a]	36.8[a]	76.5[a]	0	74[f] 28–47[d]
Synthetic diesel	CtL	780[a]	44.0[a]	85.0[a]	70.80[a]	40–130[d] 29–103[g]
	GtL				70.80[a]	13–22[d]
	BtL				0	2–7[d] 16–30[b]
Natural gas	CNG		45.1[a]	69.2[a]	56.24[a]	9–22[d]
Biogas	CBG				0	3.7[b], (-86)-23[d]
Hydrogen		n.a.	120.1[a]	0.0	0	6–88[h]
Electricity		n.a.	n.a.	n.a.	0	14–132[i]

n.a. not applicable
[a]JRC (2007a), Table 2.1.
[b]Mäkinen et al. (2006).
[c]without CCS
[d]JRC (2008).
[e]Charpentier et al. (2009).
[f]Ecoinvent database v. 2.01
[g]Vallentin (2008).
[h]Strømman et al. (2004).
[i]Depending on the future electricity Backcasts described in Sect. 2.17

The direct and upstream emissions for these fuel types are presented in Table J.1. The following text provides a detailed description on gathering the emission data for the upstream part. The direct emissions were assumed to remain constant during the time period (due to fixed stoichiometry). In electricity, CtL and GtL production, carbon capture and storage (CCS) was taken into account as described below.

Conventional Diesel

Conventional diesel is diesel fuel that is refined from crude oil originating from conventional oil reserves. So called non-conventional oil reserves such as oil sands are discussed in the next chapter.

Upstream emissions of diesel production are caused by extraction of crude oil from underground reserves, transportation (shipping) to refinery, refining and transportation to distribution. The location and quality of the oil reserve influence the size of the emissions, as well as the transportation distances and the type of the refinery and the co-products produced by the refinery. However, the variation is relatively low, especially if compared to total well-to-wheel (WTW) GHG emissions of diesel. Upstream emissions represent about 15% of the WTW emissions (12–14 g CO_2-eq/MJ fuel, while the direct emissions are about 73 g CO_2-eq/MJ fuel) (Ecoinvent database, 2007; JRC, 2008).

Diesel from Non-Conventional Oil Reserves

In addition to conventional oil, fossil diesel can be refined from raw-materials such as heavy oil (largest known reserves located in Venezuela's Orinoco belt), oil sands (large reserves in Athabasca sands in Alberta, Canada) and oil shale (mainly in the US) (IEA, 2005). According to Kouvaritakis et al. (2008), the main sources of world non-conventional oil are likely to be the Athabasca tar sands and the Orinoco extra heavy oil fields. In this section, we give a brief description of the emissions of these non-conventional diesels. Coal-to-liquid (CtL), gas-to-liquid (GtL) and biomass-to-liquid (BtL) are described in Sects. 3.1.3, 3.2.5 and 3.2.7, respectively.

In 2006, the production of synthetic crude oil (SCO) and non-upgraded bitumen from Alberta's oil sands totalled 1.2 million barrels per day, of which synthetic crude oil accounted for approximately 70% and bitumen for the remaining 30% (Charpentier et al., 2009, and the references therein). Total production is increasing rapidly as a result of high oil prices (current and expected) and the success of existing projects that draw significant investments into the sector.

Charpentier et al. (2009) reviewed and summarised 13 studies of GHG emissions associated with oil sands operations. The production of synthetic crude oil through surface mining and upgrading (SM&Up) or *in situ* and upgrading (IS&Up) processes was reported to cause emissions of 9.2–26.5 g CO_2-eq MJ^{-1} (62–164 kg CO_2-eq/bbl) for SM&Up and 16.2–28.7 g CO_2-eq MJ^{-1} (99–176 kg CO_2-eq/bbl) for IS&Up. These can be compared with 4.5–9.6 g CO_2-eq MJ^{-1}(27–58 kg CO_2-eq/bbl) of conventional crude oil production. The difference in emissions intensity between SCO and conventional crude oil production was primarily due to higher energy requirements for extracting bitumen and upgrading it into SCO. The figures provided above do not include distribution from refinery, but with the supplementary data provided by the authors,[11] it was possible to calculate the total upstream emissions for SM&Up: 12.9–30.1 g CO_2 eq /MJ for SCO and 20.8–40.7 g CO_2eq /MJ SCO for IS&Up. Some variation between studies is expected due to differences in methods, technologies studied, and operating choices. Unnasch et al. (2009) report similar CO_2 emissions for Canadian oil sands and Venezuela heavy oil.

11 supplementary data in: http://www.iop.org/EJ/mmedia/1748-9326/4/1/014005/suppdata.pdf?request-id=ed29a328-f1ef-4a56-8e4d-1d2629a76cf6

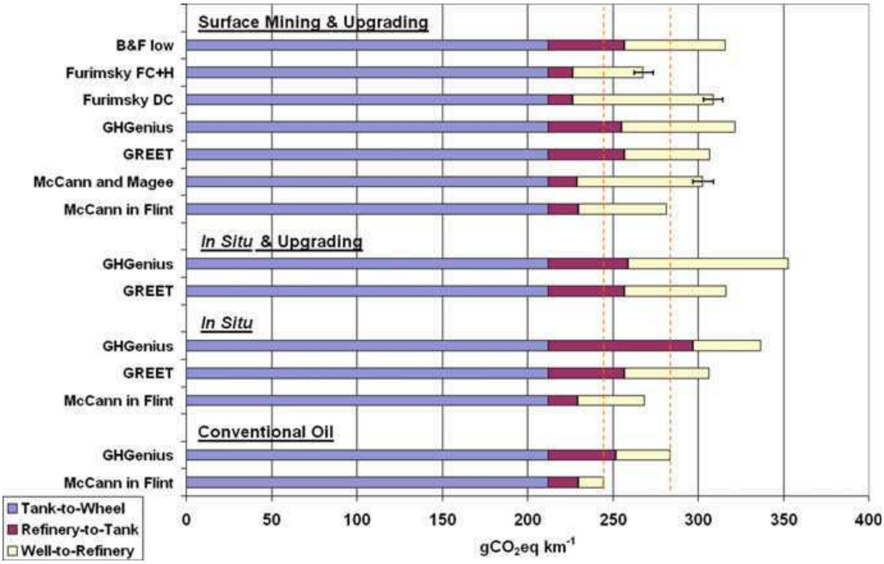

Fig. J.1 'Well-to-wheel' ghg emissions of oil sands pathways (Charpentier et at. 2009)

Coal-to-Liquid (CtL)

Coal-to-liquid (CtL) is a synthetic hydrocarbon liquid that is converted from coal. The so-called Fischer-Tropsch synthesis (FT synthesis) is the most commonly applied conversion process. Many countries have shown great interest on CtL in order to increase energy self-sufficiency and decrease dependency on oil imports. The quality of CtL fuel is high, but the conversion process is very energy and emission intensive. According to Vallentin (2008), the well-to-tank (WTT) emissions of CtL surpass those of conventional diesel by a factor of eight, and therefore carbon capture and storage (CCS) is widely perceived as a precondition for CtL commercialisation. However, according to Vallentin (2008) even at a capture rate of 90%, CtL is more CO_2-intensive than the production and combustion of conventional diesel (well-to-wheel/WTW). Therefore co-gasification ('co-firing') of biomass in CtL plants with CCS is considered necessary. The US National Energy Technology Laboratory (NETL) estimates that shares of 10–15% woody biomass by weight or 12–18% switchgrass or corn stover by weight were required to produce CtL fuels with less CO_2 emissions than conventional fuels (NETL, 2007 as cited by Vallentin, 2008). However, co-gasification raises problems related to biomass availability and transport and also requires further technical process optimisation. In terms of absolute WTW CO_2 emissions, the emissions of were reported to be 174 g/MJ (0,95 t CO_2/bbl) for CtL, 100 g/MJ (55 t CO_2/bbl) for CtL and CCS and 88 g/MJ (0,5 t CO_2/bbl) for conventional diesel (Vallentin, 2008).

The results of JRC (2008) were similar compared to those of Vallentin (2008). JRC (2008) considered the production of CtL from a typical EU coal mix in a large scale coal-to-liquids plant located in Europe, the average upstream emissions being 130 g CO_2-eq/MJ fuel. If CCS were applied, the upstream emissions would reduce significantly to 40 g CO_2-eq/MJ fuel; however, the upstream emissions still being significantly larger than in current diesel and gasoline production.

Gas-to-Liquid Diesel (GTL)

Gas-to-liquid (GtL) refers to synthetic diesel fuel which is produced by FT synthesis from natural gas. It can be either blended into conventional diesel or used as such. The GtL process is technically well-established although economic constraints have limited its large scale development (JRC, 2007b).

In terms of GHG emissions GtL seem to be more promising than CtL. However the GHG balance of the GtL depends on the system configuration and especially on the possible use of CCS. In the study of JRC (2008) a GtL plant was assumed to be installed near a remote gas supply as the most likely option, since transport of the liquid fuel is less energy-intensive than the transport of the gaseous raw material. CCS application would almost halve the upstream emissions to 13 g CO_2-eq/MJ fuel, while without CCS the average is assumed to be 22 g CO_2-eq/MJ fuel.

Natural Gas

In the business-as-usual forecasts, natural gas was not assessed as a future freight transport fuel. It was however included in the parameterization for later use in assessing mitigation action plans.

The Well-to-Wheels study by JRC (2008) analyzed several processing and transportation options for production of natural gas for transportation fuel. The upstream emissions were found to vary significantly on the basis of the raw-material (Table J.2). This is caused by differences in energy consumption and in the fraction of methane leakage (methane, the main constituent of natural gas, is a potent greenhouse gas).

Table J.2 Upstream emissions for natural gas fuel according to JRC (2008)

	g CO_2 eq/MJ
EU-mix	9
Pipeline 7,000 km	22
Pipeline 4,000 km	14
LNG – vap – pipe	20
LNG – vap – pipe – CCS	17
LNG – road – pipe	21

Biofuels

Biofuels are liquid and gaseous transportation fuels produced from renewable biomass (non-renewable biomass such as peat is excluded). Direct emissions from biofuels are not accounted for in the greenhouse gas balances, since it is assumed that the GHGs emitted during fuel combustion are absorbed in the renewing biomass stock. However, the GHGs emitted during the production of biofuels and the possibly associated land use change can offset the benefits of using renewable raw-materials.

Biofuels are often divided in 1st and 2nd generation biofuels. First generation normally refer to biofuels that already are in use, such as fatty acid methyl esters (FAME) and sugarcane bioethanol. First generation biofuels can also have fuel mix constraints when used in current engines. Second generation biofuels are made from non-edible raw-materials and are usable directly in current engines. Most of the present day biofuels can be classified as 1st generation, and the 2nd generation biofuels are expected to be commercially available around 2020.

Three types of biofuels (FAME, synthetic biofuels and biogas) were considered relevant for the assessment years 2005, 2020, 2035 and 2050. Biofuel use was minor in 2005, only 1.05% of all transport fuels used in the EU-27 were biofuels (Eurostat, 2008). However most of the biofuels were rapeseed biodiesel (mainly from Germany, France and Italy; 85% of all biofuels, EC, 2006), and since diesel is predominantly used in heavy vehicles, the fraction of biofuels used in LDFT was higher than the EU-27 average. Approximately 3% of energy was assumed to be from biodiesel in 2005.

FAME

Fatty acid methyl esters (FAME) are usually made from vegetable oils such as rape seed or palm oil. In the analysis, RME (rape seed methyl ester), was considered as a representative FAME, since in 2005 it was the most common biofuel used in the EU. Since RME-diesel production produces a considerable amount of by-products the greenhouse gas balance varies considerably between studies, depending on the allocation rules used for dividing emissions to main and by-products.

According to the Ecoinvent database (2007), RME produced in Europe (Germany, France, Austria, Italy, Czech Republic) and distributed in Switzerland had upstream GHG emissions of 74 g CO_2-eq/MJ. The study of JRC (2008) gave much lower upstream emissions for RME, varying between 28 and 47 g CO_2-eq/MJ. Four alternative uses for the co-products (seed cake and glycerine) were considered. Seed cake was assumed to be used either as animal feed or to generate biogas, which provided heat and power for the factory. Glycerine was assumed to be used either as a chemical (substituting propylene glycol), as animal feed or to generate biogas. Surplus electricity from biogas production was assumed to be marketed outside the factory. The lowest emission estimate was reported for the case in which the co-products were used to produce biogas and the highest estimate for the case in which they were used as animal feed.

Synthetic Biofuels

Synthetic biofuels or biomass-to-liquids (BtL) include a variety of biofuels produced from lignocellulosic material, such as Fischer-Tropsch (FT)-diesel and bio-dimethylether (bio-DME). Industrial scale production is anticipated to be realised around 2020. One of the main advantages of synthetic biofuels is that they can use low-grade raw-materials, which do not compete with food production, are usually cheaper and have lower emission intensities for raw-material production.

According to JRC (2008) upstream emissions for synthetic FT-diesel from wood vary between 2 and 7 g CO_2-eq/MJ fuel and for bio-DME between 2 and 6 g CO_2-eq/MJ fuel. However the calculated emissions are highly dependent on the system definition and allocation of by products. Other studies have reported emissions as high as 16–30 g CO_2-eq/MJ fuel (see e.g. Mäkinen et al., 2006).

Biogas

Biogas is produced by anaerobic digestion of organic matter in a biological process. The yield of biogas depends on the qualities of the feedstock, especially on the amount of biologically readily degradable organic matter (measured as biological oxygen demand BOD, volatile fatty acids or digestability). Biogas is most commonly made from manure and sewage, but also energy crops (maize, clover, etc.) and biowaste can be utilized.

In the FREIGHTVISION business-as-usual forecasts, biogas was not considered as a fuel for freight transport. It is however included in this report for possible later use in analysing the impacts of emission mitigation action plans (Freightvision WP 6).

According to the Ecoinvent database (2007), the upstream GHG emissions of the biogas mix provided in Swiss service stations are 1.69 kg CO_2-eq /kg methane (96 vol%), corresponding to 3.7 kg CO_2-eq/MJ.

Well-to-Wheels study (JRC, 2008) analyzed several types of raw-material sources for biogas production. The upstream emissions were found to vary significantly on the basis of the raw-material (Table J.3). The negative emissions in Table J.3 are caused by the methane emissions avoided by using biogas production instead of conventional manure treatment.

Table J.3 Upstream emissions for biogas according to JRC (2008)

Biomass source	g CO_2-eq/MJ
Municipal waste	16
Liquid manure	−86
Dry manure	0
Wheat (whole plant)	20
Corn and barley, double cropping	23

Electricity

The future development of electricity production is an external factor to the transport sector: freight transport has very limited options to influence the production technologies for electricity. However the electricity production technology mix will influence the emissions caused by electric and hydrogen engines. With inefficient and fossil fuel intensive electricity production, electric engines can have higher life-cycle emissions than diesel engines using conventional fuel.

Several backcasts for future electricity production have been proposed, the most notable being the World Energy Outlook by the IEA (2008), the backcasts of the World energy council (2007), Shell (2008) and the Energy [r]evolution backcasts by Greenpeace and EREC (2008).

Although the freight sector has limited capacity to change global electricity production, the electricity backcasts were chosen to match each of the forecasts. Therefore it was assumed that the overall attitude towards emission mitigation would be the same in the whole society as in the freight transport sector. Three Backcasts were chosen:

- *Low forecast.* Energy [r]evolution backcast describes a very strong investment in renewable energy and a shift away from nuclear and coal power.
- *Trend forecast.* Medium investments in renewable energy, nuclear power and CCS result in a stabilization of 550 ppm CO_2 in the atmosphere as predicted in the IEA World Energy Outlook 2008 middle policy backcast.
- *High forecast.* The energy sectors proceeds business-as-usual, shifts from fossil fuels to renewable and nuclear are driven by price increases as in IEA 2008 Reference Backcast.

The unit emissions of electricity were calculated as a weighted average of the emissions from the following types of power: renewable (hydropower, wind-power, solar power, forest biomass), heating oil, natural gas, coal and nuclear. The unit emissions of 2005 were used throughout the analysed period (Ecoinvent, 2007) and the results are presented in Table J.4.

Hydrogen

Hydrogen was not included in the business-as-usual forecasts. It is included in this report for possible later use in assessing mitigating action plans.

Industrial hydrogen is currently made from natural gas. Strømman et al. (2004) assessed the life cycle impacts of large scale hydrogen production. According to their analysis, the emission intensity was 84 g CO_2-eq/MJ hydrogen gas, if carbon capture and storage was not applied for the carbon in the methane feedstock. With CCS the GHG emissions were 20 g CO_2-eq/MJ and with process heat from hydrogen, a further reduction to 6 g CO_2-eq/MJ was obtained.

Table J.4 The development of the net electricity produced by fuel type

Low forecast	Emissions	Primary energy		Greenpeace and EREC (2008)			
	g CO_2-eq/MJ	Fossil MJ/MJ	Total MJ/MJ	2005	2020	2035	2050
Hydro	6	0	1.07	9%	13%	13%	16%
Wind	3	0.03	1.13	2%	15%	28%	46%
Solar	6–23	0	1.52	0%	7%	9%	14%
Biomass	3	0.05	1.33	3%	7%	10%	11%
Oil	115	1.33	3.52	4%	1%	1%	0%
Natural gas	89	1.21	1.43	21%	28%	27%	12%
Coal	319	1.58	3.84	31%	15%	6%	0%
Nuclear	2	2.74	3.52	30%	12%	4%	0%
Average CO_2-eq/MJ				123	77	47	14
Average Fossil MJ/MJ				1.48	1.00	0.65	0.24
Average Total MJ/MJ				2.85	1.97	1.56	1.21
Trend forecast	**Emissions**	**Primary energy**		**IEA (2008) 550 stabilization**			
	g CO_2-eq/MJ	Fossil MJ/MJ	Total MJ/MJ	2005	2020	2035	2050[a]
Hydro	6	0	1.07	9%	12%	12%	
Wind	3	0.03	1.13	2%	6%	10%	
Solar	6–23	0	1.52	0%	0%	4%	
Biomass	3	0.05	1.33	3%	6%	6%	
Oil	115	1.33	3.52	4%	1%	1%	
Natural gas	89	1.21	1.43	21%	22%	25%	
Coal	319	1.58	3.84	31%	28%	20%	
Nuclear	2	2.74	3.52	30%	24%	23%	
Average CO_2-eq/MJ				123	113	88	65
Average fossil MJ/MJ				1.48	1.39	1.13	0.85
Average total MJ/MJ				2.85	2.57	2.33	2.00

Table J.4 (continued)

High forecast	Emissions	Primary energy		IEA (2008) 550 stabilization			
	g CO_2-eq/MJ	Fossil MJ/MJ	Total MJ/MJ	2005	2020	2035	2050
Hydro	6	0	1.07	9%	11%	10%	12%
Wind	3	0.03	1.13	2%	11%	14%	12%
Solar	6–23	0	1.52	0%	1%	3%	2%
Biomass	3	0.05	1.33	3%	5%	5%	5%
Oil	115	1.33	3.52	4%	1%	1%	1%
Natural gas	89	1.21	1.43	21%	23%	26%	28%
Coal	319	1.58	3.84	31%	27%	23%	33%
Nuclear	2	2.74	3.52	30%	20%	16%	8%
Average CO_2-eq/MJ				123	111	101	133
Average fossil MJ/MJ				1.48	1.38	1.27	1.66
Average total MJ/MJ				2.85	2.46	2.26	2.33

Emission intensities and energy consumption from Ecoinvent (2007). Electricity generation fractions from IEA (2008), Greenpeace and EREC (2008)
[a]For the trend backcast, the emissions and energy consumptions for 2050 were extrapolated from previous values

In the future however, hydrogen generation is likely to be from renewable energy sources and nuclear energy (EC, 2007). In these cases, the emission intensity is similar to that of electricity or biomass.

Introduction of CCS

Carbon capture and storage (CCS) refers to technologies in which CO_2 released from the use of fossil fuels is captured and stored in long-term storages such as deep sea reservoirs or other geological storages. It can be a significant factor in improving the CO_2 balance of fuel and electricity production. However, the use of CCS generally leads to increased energy use, as capture, treatment and storage of CO_2 is energy intensive.

Currently, small scale capture of CO_2 from industrial and power plants is already possible but large scale CCS is not yet in use because of economical and technical constrains. Some major reservoirs suitable for storage have been identified, but more work is still needed in this area. Traditionally CO_2 has been injected to oil fields to enhance recovery, but first experiments on deliberate CO_2 storage have been done in North Sea. Next steps in the development of CCS technology would include cost reduction, improvement of the technology's safety and prevention of any losses (IEA, 2009). Even though CCS is considered as major possibility to reduce CO_2 emissions of fossil fuel use, lack of reservoirs and high transportation costs limit its introduction. In the Freightvision project, CCS was considered to be introduced as in IEA (2008) (Table J.5).

Table J.5 Estimated introduction of CCS based on IEA World Energy Outlook (2008)

	2005	2020	2035 (%)	2050 (%)
Low forecast	–	–	40	80
Trend forecast		–	5	10
High forecast		–	–	–

According to Brandt & Farrell (2007) CCS is not likely to improve the CO_2 performance of low-grade oil production (tar oil, oil shale) because the emissions are from dispersed processes. However, emissions from GtL and CtL production concentrated and therefore the potential for use of CCS is better. In our estimate, we assumed that CCS would only be used in GtL and CtL production. Costs of applying CCS to BtL for carbon negative fuels were considered prohibitive.

Fuel used in Propulsion Technologies

It was assumed that the share of biofuels would increase as presented in Table J.6. Biofuels were assumed to consist of RME (50%) and BtL (50%) in 2020 and after that all BtL. 2nd generation biofuels are expected to be on the market around the year 2020 and the sustainability criteria on biofuels were assumed to be widely used.

At the same time, conventional crude oil was assumed to be replaced slowly by non-conventional fuels such as heavy oil, oil tar sands and oil shale, coal-to-liquids and gas-to-liquids. Based on Kouvaritakis et al. (2008) we assumed that 90% of non-conventional diesel would be heavy oil, oil tar and oil sand, 5% CtL and 5% GtL.

Table J.6 Estimated use of different fuels in road freight (MJ/MJ)

Diesel engine	2005	2020	2035	2050
Conventional diesel	97%	82.5%/ 80%/ 70%	70%/ 65%/ 45%	62.5%/ 50%/ 10%
Non conventional diesel (heavy oil, oil tar, oil shale, CtL, GtL)	–	5%/ 10%/ 20%	10%/ 20%/ 40%	10%/30%/ 70%
Biofuels	3%	12.5%/ 10%/ 10%	20%/ 15%/ 15%	27.5%/ 20%/ 20%

First = low baseline forecast / second = trend baseline forecast / third = high baseline forecast

Engine Fuel Efficiency

The engine fuel efficiency governs the amount of fuel energy needed to supply the mechanical energy for propulsion. Therefore it is one of the most influential factors in the model. The engine efficiency was assumed to develop as presented by Schmiele

Table J.7 Estimated development of engine efficiency

	2005	2020	2035	2050
Diesel engine	42%	51% / 48% / 42%	55% / 53% / 42%	55% / 55% / 42%
Electric engine	80%	No change	No change	No change

First = low baseline forecast / second = trend baseline forecast / third = high baseline forecast

et al. (2009) in Freightvision D 5.2 (Table J.7). The figures are based on preliminary targets set in the 21st century truck project (US Department of Energy, 2007), the review by Johnson et al. (2008) and Telias et al. (2009).

Propulsion used in Vehicles

The propulsion used in vehicles was included for backcasts, in which hybrid or fuel cell propulsion systems would be introduced. In the business-as-usual forecasts however these technologies were not introduced into heavy vehicles. Therefore the fraction of diesel engines is 100% in all forecasts, except for electric trains.

While this parameter was fixed in the three forecasts, it was kept in the model for assessing action plans where fuel cells would penetrate the market. The matrix notation also allows the consideration of many propulsion units in the same vehicle (i.e. sails and engines in ships).

Table J.8 Estimated development of propulsion used in vehicles

	2005 (%)	2020 (%)	2035 (%)	2050 (%)
Diesel engine				
Trucks 9–40 t	100	100	100	100
Diesel trains	100	100	100	100
IWW	100	100	100	100
Electric engine				
Electric trains	100	100	100	100

Mechanical Work/Transport Unit

Mechanical work/transport unit describes the external resistances that have to be overcome in order to move the load at a constant velocity. It applies to average conditions and assumes a full payload (100% of capacity). The inefficiencies of incomplete loading are included as an additional parameter: the additional work needed (Sect. 3.7).

The 2005 situation is taken from the Finnish emission inventory for 40 t, 25 t and 9 t payload trucks (http://lipasto.vtt.fi). The baseline backcast for power requirement

reductions was assumed to follow the 21st century truck specifications, which predicted a 30% reduction in power demand by 2012 (mainly through rolling resistance, aerodynamics and auxiliary load minimization) (US Department of Energy, 2007). However, the targets were shifted to be met only half-way in 2020 and fully only in 2035, in order to better reflect the review of the 21st truck project (Johnson et al., 2008). (In the review, it was stated that it is highly unlikely that the targets for rolling resistance and aerodynamics would be met by 2015.) The efficiency was assumed to improve similarly in the low and trend forecasts. In the high forecasts, however, it was assumed that these technologies would not get a significant market share and consequently the power requirements would be fixed at the 2005 level.

No efficiency improvements were assumed for rail and IWW since the effect of these improvements would be minimal without major changes in the modal split in the business-as-usual forecasts.

Table J.9 Estimated development of the work demand of fully loaded vehicles (MJ_{wheel}/tkm)

MJ/tkm	2005	2020	2035	2050
40 t truck	0.19	0.16	0.13	0.13
25 t truck	0.25	0.21	0.18	0.18
9 t truck	0.37	0.32	0.26	0.26
Electric train	0.12	No change		
Diesel train	0.15			
Container ship	0.13			
Cargo ship	0.10			

Note: this is not a fuel demand, which is affected by engine efficiency

Additional Work Needed

The factor for additional work needed was used to include inefficiencies in logistics to the energy requirements. Two main sources of inefficiencies are considered: empty haulage and load factor.

The i factor was expressed as the amount of additional work needed to move one tkm compared to the theoretical minimum

$$\mathbf{i} = \mathbf{E}_{act}/\mathbf{E}_{min} - 1$$

The $\mathbf{E}_{min}$ is the figure reported for the work requirement at fully loaded vehicle. $\mathbf{E}_{act}$ is calculated from the distances d of loaded and empty driving required to move 1 tkm:

$$\mathbf{E}_{act} = \mathbf{E}_{load} * d_{loaded}(\text{km/tkm}) + \mathbf{E}_{empty} * d_{empthy}(\text{km/tkm})$$

The distances of empty and loaded driving are calculated from the empty haulage fraction and from the load factor.

The work demand for $\mathbf{E}_{load}$ is calculated based on data from lipasto.vtt.fi on work requirements for full, 70% load and empty loads by assuming a linear correlation:

$$\mathbf{E}_{load} = (\mathbf{E}_{full} - \mathbf{E}_{70\%})/30\% * \text{loading factor} + \mathbf{E}_{empty}$$

In addition to these, the ITS systems work to reduce the i-factor.

In all forecasts, the load factor was expressed as average loads (Schmiele et al., 2009). These were transformed to the empty haulage and load factor figures by assuming a constant empty haulage fraction (24%). The derived load factors and i-factors are presented in Table J.10.

For IWW and rail these factors were not considered, since the values obtained for the work requirements included the average inefficiencies already (Table J.10).

Table J.10 Inefficiencies in loading causing additional energy expenditure

		2005	2020	2035	2050
Input	Distance weighted load (tkm/vkm)	9.81	10.8/10.3/ 9.81	11.2/10.7/ 9.81	11.5/11.0/ 9.81
Adjusted	Empty driving (vkm/vkm)	24%	24%	24%	24%
	Load factor (t/t)	52%	57%/54%/ 52%	59%/56%/ 52%	61%/58%/ 52%
Used in model	i-factor	1.09	0.92/1.00/ 1.09	0.86/0.94/ 1.09	0.82/0.89/ 1.09

First = low baseline forecast/second = trend baseline forecast/third = high baseline forecast

Vehicles by Mode

The fleet composition data was difficult to obtain. In the TREMOVE project, fleet composition was based on few road counts in Germany and in Italy (Knockaert et al., 2004). The road count data presented for highways had 16% of vehicles with a payload of less than 9 t (total mass less than 16 t), The road count data was weighted with the vehicle payload to get an rough estimate of the freight moved by different sized trucks (Table J.11). Correspondently 96% of freight volume in highways was assumed to be moved by heavy 25 t payload trucks, the remaining being on lighter (less than 9 t) payload trucks.

Although long and heavy vehicles (gigaliners, megatrucks, etc.) have been proposed, they were not in widespread use in 2005 outside Finland and Sweden. They were also excluded from the three forecasts and reserved as an additional measure.

The electrification rate for Europe 2005 was obtained from Ecoinvent 2.01 database. It was forecasted as described in D5.2 (Schmiele et al., 2009).

Table J.11 Highway count data was weighted with the payload capacity to get the distribution of freight demand to different sized trucks

Vehicle size (t)	Payload (t)	Highway counts (%)	Counts weighted by payload (%)
3.5–7.5	3.5	12	2
7.5–16	9	4	2
16–32	20	39	40
over 32	25	45	56

Table J.12 The fleet composition data used in the forecasts

	2005 (%)	2020	2035	2050
Rail				
Electric	64	66% / 65% / 65%	70% / 67.5%/ 66%	74% / 70% / 68%
Diesel	36	34% / 35% / 35%	30% / 32.5%/ 34%	26% / 30% / 32%
Road				
40 t truck	0	No change		
25 t	96			
9 t	4			
Inland waterways				
Container ship	100	No change		

First = low baseline forecast/second = trend baseline forecast/third = high baseline forecast

Modal Split

The modal split was assumed to develop as presented by Schmiele et al. (2009). The modal split was assumed to be the same in all three forecasts (Table J.13).

Freight Volume

The freight volume of LDFT was assumed to develop as presented by Schmiele et al. (2009). The assessment was based on the information given by (Anders et al., 2009) on

Table J.13 Estimated development of modal split

	2005 (%)	2020 (%)	2035 (%)	2050 (%)
Rail	18.8	20.1	20.5	21.0
Road	75.7	73.9	73.7	73.4
Inland waterways	5.5	6.0	5.8	5.6

Table J.14 Estimated development of freight volume (LDFT)

	2005	2020	2035	2050
Volume, billion tkm	2183	2792/ 2939/ 3027	2965/ 3295/ 3460	2792/ 3490/ 3839

First = low baseline forecast/second = trend baseline forecast/third = high baseline forecast

the recent development of the freight transport demand in EU-27. The share of short distance freight transport (SDFT) was assumed to decrease from 7.5% of total freight transport in 2005 to 5.0% in 2050.

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